

BETTER PUBLIC TRANSPORT. BETTER PRODUCTIVITY.

The economic return on public transport investment



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- best practice in customer service, particularly through the use of new technology.

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CONTENTS

LIST OF FIGURES	2
EXECUTIVE SUMMARY	3
01 INTRODUCTION	7
1.1 SETTING THE SCENE	8
1.2 HOW THIS REPORT CONTRIBUTES	9
1.3 STRUCTURE OF REPORT	10
02 THE MACROECONOMIC IMPERATIVE: FROM 1900 TO 2040	11
2.1 THE THREE STAGES OF ECONOMIC DEVELOPMENT	12
2.2 TRANSPORT REQUIREMENTS THROUGH THE STAGES OF DEVELOPMENT	14
2.3 THE SERVICE SECTOR SUPPLY CHAIN	16
03 THE URBAN IMPERATIVE	17
3.1 THE IMPORTANCE OF AUSTRALIA'S URBAN AREAS	18
3.2 THE TRANSPORT REQUIREMENTS OF MAJOR URBAN AREAS	21
04 THE ECONOMIC RETURN ON PUBLIC TRANSPORT INVESTMENT	25
4.1 ECONOMIC RETURNS FROM THE EPPING TO CHATSWOOD RAIL LINK	27
4.2 INTERNATIONAL AND DOMESTIC CASE STUDIES	32
05 CONCLUSION	37
APPENDIX A: GEM	39
REFERENCES	40

LIST OF FIGURES

FIGURE		PAGE
E1	GDP by sector: Australia 1900 to 2040	3
E2	Economic output / employee	5
E3	Drivers of economic growth in Macquarie Park	5
1	GDP by sector: Australia 1900 to 2040	13
2	Employment by sector: Australia 1900 to 2010	13
3	The five most important urban locations to the Australian economy	19
4	Relationship between mass transit usage and job density, Sydney 2006	20
5	Mode of travel to work for commuters in Australia's four largest cities	21
6	Annual private vehicle kilometres per person	22
7	Modal share for urban passenger transport 1900-2011	23
8	Total metropolitan passenger task performed by Australian mass transit modes 1900-2011	23
9	Estimated economic and job dividend to Macquarie Park post the opening of rail line in 2009	28
10	Economic output per employee	29
11	Drivers of economic growth in Macquarie Park	29
12	Docklands Light Rail	33
13	Jubilee Line Extension	33
14	Canary Wharf vs. London Employment (Index, 2000 = 100)	35
15	Sectoral employment in Canary Wharf in 2001 and 2012	35

EXECUTIVE SUMMARY

A well-functioning transport system is vital to the productivity of all economies, including Australia's.

This has been increasingly recognised by federal, state and local governments and many have given greater priority to transport infrastructure funding and expansion.

The Tourism & Transport Forum (TTF) commissioned PwC to prepare this report as part of its contribution to public discussion about the role of public transport in Australia's modern service economy. The report finds that improved public transport must be seen as an essential part of national efforts to boost economic productivity and should receive the same level of commitment from all levels of government, including the Commonwealth, as other transport-related infrastructure projects.

While the link between improved freight, port and road infrastructure and economic growth is accepted by governments, there is a less clear understanding of the productivity benefits that accrue from expanded public transport infrastructure, which this report seeks to address.

PURPOSE OF THIS REPORT

The purpose of this report is to provide the granular evidence base to better understand the contribution of public transport to productivity improvements. Recognising existing work on agglomeration, this report expands our understanding of the links between transport and productivity by exploring two additional lines of questioning:

- Why is the role of public transport so important to Australia's future economic prospects? This considers the trajectory of the Australian economy from 1900 through to 2040, with a particular focus on the location of economic activity.

- What actually happens to a local economy and local productivity once an investment in transport accessibility has been made? This question is examined through *ex-post* analysis of the economies along the recently opened Epping to Chatswood Rail Link in Sydney.

By answering these questions, the report provides new perspectives on the planning, prioritising and delivering of transport infrastructure to ensure that future investments maximise the productive capacity of the Australian economy.

THE MACROECONOMIC IMPERATIVE FROM 1900–2040

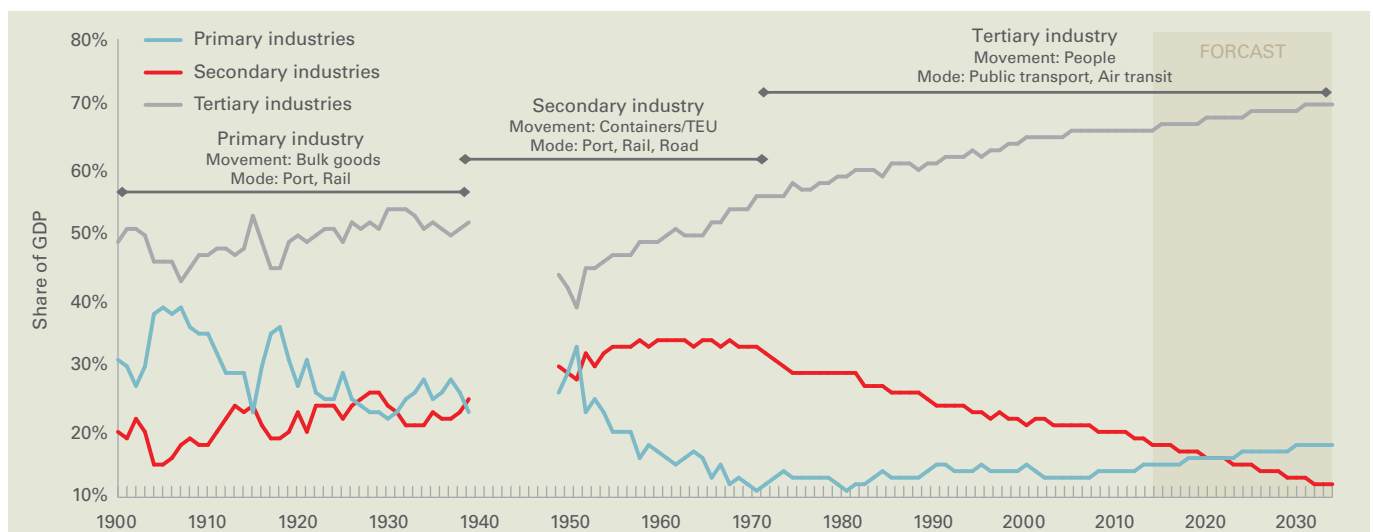
The most productive transport infrastructure investment in a country is one that supports the economy's key needs. This pattern plays out consistently through history, with Australia being no exception (Figure E1).

Primary production and resource extraction requires rail and port infrastructure designed for the transport of bulk primary products. Modern manufacturing (secondary industry) usually requires the use of containerised freight and the associated road and port infrastructure to allow for its movement.

The success and competitiveness of service (tertiary) economies rests upon the labour market. People are the key inputs to production, with the ability to efficiently move these people to, and between, dense urban clusters of economic activity the cornerstone of a successful service sector supply chain.

Because of change in the structure of all economies, the most productive investment in transport infrastructure 20 years ago is not necessarily the most productive investment today and almost certainly won't be in 2040. Flexibility and foresight are required.

Figure E1: GDP by sector: Australia 1900 to 2040



PwC analysis and forecasts. Sources: ABS, Butlin (1984) data, cited by Glenn Stevens (2012) "The Australian Economy: Some Perspective"
Note: Break in time series between 1940–1950

In Australia, the service sector currently accounts for 85 per cent of all jobs. By 2040 this sector will make up 70 per cent of our economic output. This activity is, and will continue to be, concentrated in high density, yet geographically dispersed, clusters in urban areas. Quite simply, location matters.

For example, the CBDs of Australia's five largest capital cities together account for 12.3 per cent of total economic output. Yet these areas only house 0.6 per cent of Australia's total residential population.¹ Efficiently providing access to and between these key pockets of national economic significance is therefore critical to the future productive growth of Australia.

This historical perspective and the importance of location reinforce the need to transparently and robustly identify, understand and prioritise solutions to existing and rapidly emerging capacity constraints in major urban areas. These constraints are of national significance and hold the potential to unlock the greatest productivity capacity in our economy's most important sectors. These constraints will require, where possible, the more efficient use of existing transport infrastructure and investment in further public transport capacity.

EMPIRICAL EVIDENCE OF THE IMPORTANCE OF PUBLIC TRANSPORT TO ECONOMIC GROWTH

Both in Australia and overseas, there is a lack of *ex-post* analysis of the impacts of public transport investment on local economies, jobs, business and government. This lack of empirical evidence is in stark contrast to the importance placed on the link between public transport and productivity in policy forums, project business cases and public debate.

This report begins to define this relationship within the Australian context. It does this by undertaking a detailed case study of the impact that the announcement and opening of the Epping to Chatswood Rail Link had on the clusters of economic activity at Epping, Macquarie Park, North Ryde and Chatswood (the station locations). This analysis is possible through the use of a granular new dataset for estimating economic activity and productivity across 2,214 small areas within Australia from 2001 to 2013. Controlling and normalising for a range of other potential variables, the initial findings suggest a strong link between significantly improved public transport accessibility and more productive economic growth.

Stronger economic growth at Macquarie Park

Macquarie Park, a location supported by strong local planning directions, was growing rapidly prior to the improved access

to labour markets it gained through its connection to the opening of the rail in 2009. The findings suggest that upon opening the rail line in 2009:

- The Macquarie Park economy grew by an additional 1.56 per cent to 2.44 per cent per annum.² This acceleration in economic growth bucks the trend seen across Australia of lower rates of economic growth post the 2008 GFC and has delivered an estimated **additional \$1.02 billion to \$1.49 billion present value economic activity** to the local economy.³ This is a substantial return considering the relatively short time in operation and the initial reported capital investment of an estimated \$2.3 billion.⁴
- Jobs growth in Macquarie Park was an extra 2.19 per cent to 2.65 per cent per annum.⁵ In aggregate, this implies the workforce in Macquarie Park is estimated to have increased by 32.5 per cent since gaining the improved access to labour markets. In other locations around Australia, NSW and Sydney, job growth over this period was slow or had even contracted.

More productive growth at Macquarie Park

Economic growth is most sustainable when it is matched by increasing levels of productivity – i.e. the labour and capital invested within the location delivers higher returns. In the case of Macquarie Park, the *ex-post* analysis indicates:

- Productivity (measured by the proxy of economic output per employee) has grown significantly faster than elsewhere in Sydney and NSW. This growth began upon commencement of construction, with a further acceleration upon commencement of services (Figure E2 opposite).
- Returns to businesses in the area have led this strong economic and productive growth (Figure E3 opposite). While there has been strong growth in wages and government tax revenues, business profitability has seen the sharpest rise since the commencement of services.

These findings align with the significant impact that public transport investment has delivered to high value-add jobs, and the location of these jobs, overseas. The Jubilee Line Extension and Docklands Light Rail in London reinforce the fact that public transport accessibility is a key ingredient for driving economic growth, job growth and urban regeneration. There is no doubt, especially in the case of the Jubilee Line Extension and Docklands Light Rail, that the success of the location and performance of the high value-add service sectors here was underpinned by these landmark public transport projects.

1. PwC Geospatial Economic Model (GEM). All values are real FY13. Locations are based in ABS SA2 classifications

2. Range dictated by controlling for a range of industry, locational and macroeconomic variables which influence the economy at either an industry, Sydney-wide, state or national level

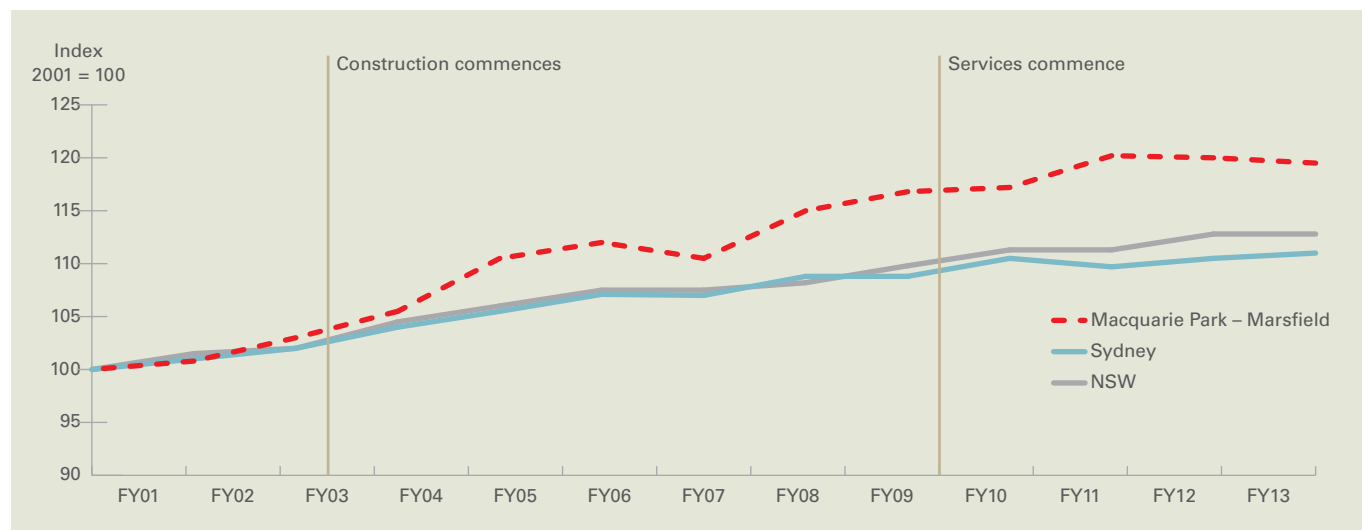
3. *Ex-post* appraisal of economic benefits undertaken using the following parameters: base year - 2001 (date of last update for the Parramatta to Chatswood Economic and Financial Evaluation). Real economic discount rate – 7.0 per cent. The results reflect the range of economic growth that is estimated to stem from opening the rail line, after normalising for other economic, industry and locational variances

4. *Sydney Morning Herald*, Epping to Chatswood Rail Link opens, February 23, 2003. It is assumed the quoted cost is real, \$2009

5. Range dictated by controlling for a range of industry, locational and macroeconomic variables which influence the economy at either a Sydney-wide, state or national level

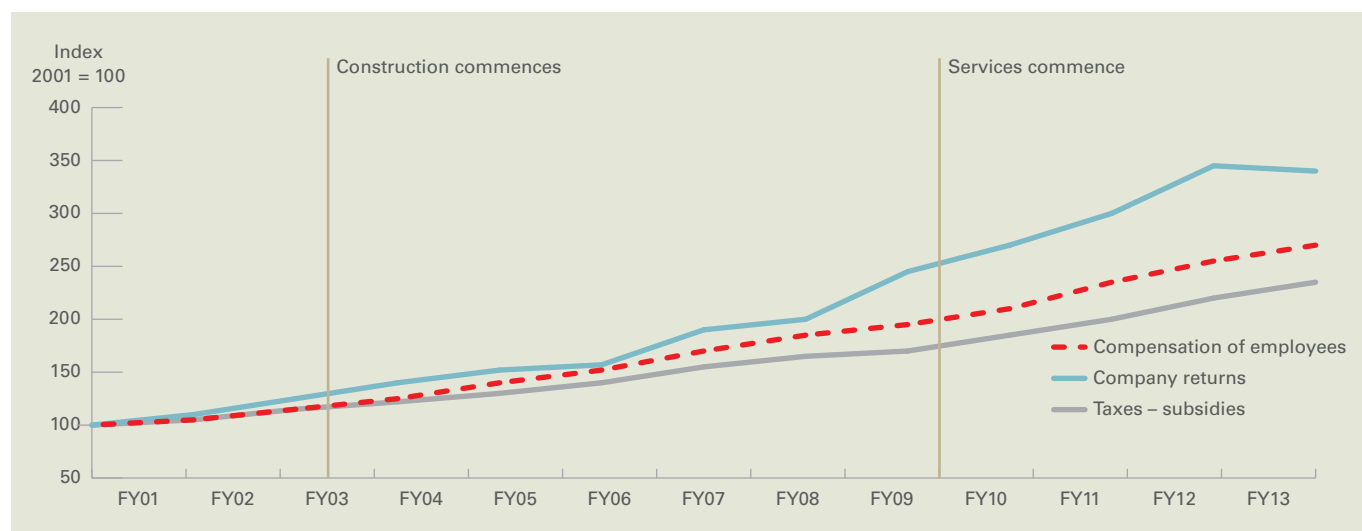


Figure E2: Economic output / employee



Source: PwC analysis using the PwC Geospatial Economic Model (GEM) V1.0. 2014

Figure E3: Drivers of economic growth in Macquarie Park



Source: PwC analysis using the PwC Geospatial Economic Model (GEM) V1.0. 2014

SIX STEPS TO ENSURE PUBLIC TRANSPORT EXPANDS AUSTRALIA'S PRODUCTIVE CAPACITY

Through expanding the current understanding of transport's role in a productive economy, six recommendations become apparent.

1. Ensure that Australia's transport infrastructure aligns with and supports the changing structure and future competitiveness of our economy and its industries.
2. Identify the locations in Australia with the greatest current and future economic significance. Incorporate the understanding of these locations into the current:
 - a. Infrastructure Australia criteria for Nationally Significant infrastructure investment.
 - b. Identification and prioritisation of projects and policies in state-based infrastructure and transport strategies.
3. As a priority, identify the critical high-value service sector clusters within cities to:
 - a. Assess these clusters' current linkages to appropriate labour markets.
 - b. Prioritise evidence-based solutions to existing and emerging transport capacity constraints which hinder the current performance and future growth of these key clusters.
4. Maximise the productive capacity of existing public transport infrastructure assets by exploring and testing all governance, regulatory or operating changes that could lead to the more efficient and effective use of this asset base.
5. Ensure all decisions on transport investment by both federal and state governments are underpinned by rigorous, transparent cost-benefit analysis. Federal transport funding should be modally-neutral and support both road and public transport infrastructure projects based on the outcomes of cost-benefit analysis and the needs of the modern economy.
6. Undertake and publish *ex-post* analysis on completed investments at five and then 15 year intervals. Use this local information to refine and improve Australian transport appraisal.

01 INTRODUCTION



INTRODUCTION



PRODUCTIVITY ISN'T EVERYTHING, BUT IN THE LONG RUN IT IS ALMOST EVERYTHING. A COUNTRY'S ABILITY TO IMPROVE ITS STANDARD OF LIVING OVER TIME DEPENDS ALMOST ENTIRELY ON ITS ABILITY TO RAISE OUTPUT PER WORKER.

PAUL KRUGMAN, 1997⁶

1.1 SETTING THE SCENE

Productivity underpins the competitiveness of countries, cities, businesses and individual workers. Productivity improvements are required to increase standards of living and to support population growth. Without productivity growth, an expanding population requires us to draw more heavily on our finite natural resources or to accept lower standards of living. Put another way, improvements in productivity are the foundation of a strong economy, higher material standards of living and provide the basis to enhance many non-material factors affecting quality of life.

Productivity improvements improve wellbeing in a number of ways. Productivity improvements can increase company

profits and the wages of employees. Businesses that are more productive are able to produce more output at lower cost, reduce prices for consumers and better deliver the services customers desire.

However, over the past decade Australia's productivity growth has slowed to a crawl and in some cases plateaued.⁷ Adding to this are recent concerns around the potential drivers for growth in our economy post the resource investment boom.

This report explores how transport, and public transport in particular, can play a key role in driving productivity and underpinning the economic foundations of our economy.

6. Krugman, Paul R. (1997) *The Age of Diminished Expectations: U.S. Economic Policy in the 1990s*, third edition, MIT Press, Cambridge, Massachusetts, p11

7. Eslake, Saul (2011) 'Productivity: The Lost Decade', in Gerard, Hugo and Kearns, Jonathan (eds) *The Australian Economy in the 2000s*, Proceedings of a Conference, Reserve Bank of Australia, Sydney, online at: <http://www.rba.gov.au/publications/confs/2011/pdf/eslake.pdf> (accessed 2 January 2014)



1.2 HOW THIS REPORT CONTRIBUTES

There have been many reports and discussions into productivity and transport infrastructure in Australia in recent years, particularly in the context of the need to increase the overall productivity of the Australian economy. Much of the understanding about public transport and its role in underpinning productive growth in cities looks at the theoretical process of *how*. *How* public transport can underpin efficient and productive economic growth. *How* the theory of agglomeration economies and dense economic clusters form and how they are supported by public transport accessibility. In this report, prepared by PwC for the Tourism & Transport Forum, we expand the current understanding of this topic in two areas.

First we look at why public transport's role in productive economic growth matters, taking a view that stretches back to 1900 and forward to 2040.

We then look at what investment in public transport actually does to both the localised and broader economy. To answer this, we use new data to quantify the economic dividend resulting from the improved provision of public transport infrastructure in an urban location, including a specific analysis of the return from the Epping to Chatswood Rail Link to the Macquarie Park economy. This *ex-post* analysis provides a step change in the evidence base for linking public transport investment to tangible changes in employee, business and government output and productivity.

The two areas provide the broader macroeconomic imperative and granular evidence base to better understand the links between evidence-based public transport investment and the productive capacity of our economy.

Image courtesy of Department of Planning, Transport and Infrastructure



1.3 STRUCTURE OF REPORT

This report is structured as follows:

- In chapter 2, we explore the macroeconomic imperative from 1900 to 2040 to show why public transport investment is critical to our nation's productive capacity. We finish the chapter by introducing the concept of the service sector supply chain and the role public transport plays in underpinning our high value-add service sector.
- In chapter 3, we identify the small number of locations within Australia that generate close to 25 per cent of our country's economic output. These locations are critical to the productive growth of the Australian economy, so we examine the transport required to efficiently underpin their growth and maximise their future economic returns.
- In chapter 4, we outline the economic return from public transport investment by presenting a series of case studies on what public transport infrastructure has done to enhance productivity in urban settings. This is done by:
 - » First, using a new granular economic dataset, we examine the impact that the opening of the Epping to Chatswood Rail Link has had on a number of productivity metrics including: economic growth, employment growth, employee productivity, industry density, business profitability and government tax revenues.
 - » Second, we calibrate the findings from the Epping to Chatswood Rail Link analysis to other domestic and international *ex-post* case studies, to demonstrate and comment on the nuances of substantial productivity improvements associated with public transport investment.

Throughout the report, a series of six recommendations is made. Adopting these recommendations will expand the evidence base and ensure public transport investment maximises the productive capacity of our economy.

02 THE MACROECONOMIC IMPERATIVE: FROM 1900 TO 2040



THE MACROECONOMIC IMPERATIVE: FROM 1900 TO 2040

THERE ARE SIGNIFICANT OPPORTUNITIES FOR ADDITIONAL INVESTMENT IN TRANSPORTATION INFRASTRUCTURE AND FOR USING THE EXISTING INFRASTRUCTURE MORE EFFICIENTLY. DOING SO WOULD PROMOTE PRODUCTIVITY GROWTH IN AUSTRALIA AND CONTRIBUTE TO ADVANCEMENT OF THE OVERALL WELFARE OF OUR CITIZENS.

DEPUTY GOVERNOR OF THE RESERVE BANK OF AUSTRALIA, PHILIP LOWE⁸

Different industries dominate different stages of a country's economic history. These industries require different transport infrastructure to support them. This has two implications:

1. The transport investment requirements of a country will shift as its economy grows and changes. The most productive investment in transport infrastructure 20 years ago is not necessarily the most productive investment today or in 2040. Flexibility and foresight are required.
2. The most productive investment in transport infrastructure either enhances the competitive edge of industries within the country or matches the current and emerging economic and industry needs of the economy.

Economies focused on primary production and resource extraction require rail and port infrastructure to support the transport of bulk primary products. Similarly, manufacturing is facilitated by containerised freight and the associated transport infrastructure that moves it. By contrast, in the services sector, especially the high value-add services sector, the most important market is the labour market, with the transport system needing to efficiently move people to, and between, the centres of economic activity.

In this chapter, we review the stages of economic development and their associated transport needs. This indicates that a focus on the service sector supply chain – moving people to and between major centres of concentrated economic activity – is of increasing importance to our population's wellbeing and nation's economic fortunes.

2.1 THE THREE STAGES OF ECONOMIC DEVELOPMENT

Models of economic development often divide economic activity into three main areas: primary (dominated by the extraction of raw materials and agricultural production),

secondary (focused on manufacturing) and tertiary (service-based).⁹ In this model, the proportion of the working population engaged in the primary sector reduces through the process of economic development, manufacturing activities undergo an initial increase before decreasing, while service sector activity steadily increases and comes to dominate the economy.

This pattern of economic development has been broadly followed by Australia since 1900 (Figure 1 and Figure 2):

- **Primary, until World War II:** The agriculture and mining sectors began the century as major contributors to national output and employment, but have declined steadily as a share of national totals since around WWII. Substitution of capital for labour in primary industries has resulted in low employment in those sectors, despite strong mining output in recent years.
- **Secondary, WWII–1970s:** Over the first 50 years of the century, manufacturing employment doubled as a proportion of the working population, largely at the expense of primary sector employment in agriculture and mining. However, after peaking between 1950 and 1970, manufacturing's share of output has declined markedly. Substitution of capital for labour is also evident in manufacturing, which has reinforced declining employment in the sector.
- **Tertiary, 1970s–today:** Service sector output has grown steadily since the 1950s and will represent an estimated 70 per cent of Australia's economic output by 2040. Employment in Australia's service sector has also increased to around 85 per cent of the total employment, up from 55 per cent in 1950.¹⁰ To summarise, 70 cents in each dollar of Australia's output is going to stem from an industry where efficiently moving a very large proportion of our working population is the key to success.

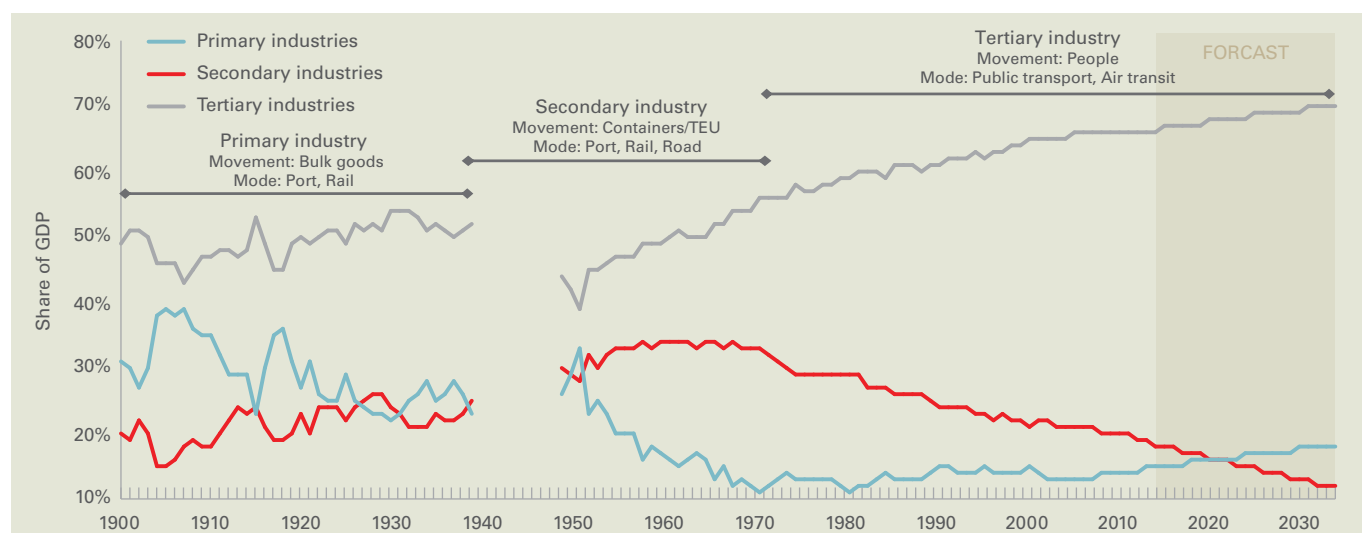
8. Lowe, Philip (2013), *Speech to the IARIW-UNSW Conference on Productivity Measurement, Drivers and Trends*, Sydney - 26 November 2013, online at: <http://www.rba.gov.au/speeches/2013/sp-dg-261113.html#f7> (accessed 2 January 2014)

9. Clark, Colin (1957), *The Conditions of Economic Progress*, Macmillan, London

10. If we exclude construction from services, as is sometimes done, the proportion of service sector employment is still over 75 per cent of total employment. For example, see Lowe, Philip (2012) *The Changing Structure of the Australian Economy and Monetary Policy*, Address to the Australian Industry Group 12th Annual Economic Forum, Sydney - 7 March 2012, online at: <http://www.rba.gov.au/speeches/2012/sp-dg-070312.html> (accessed 23 December 2013)

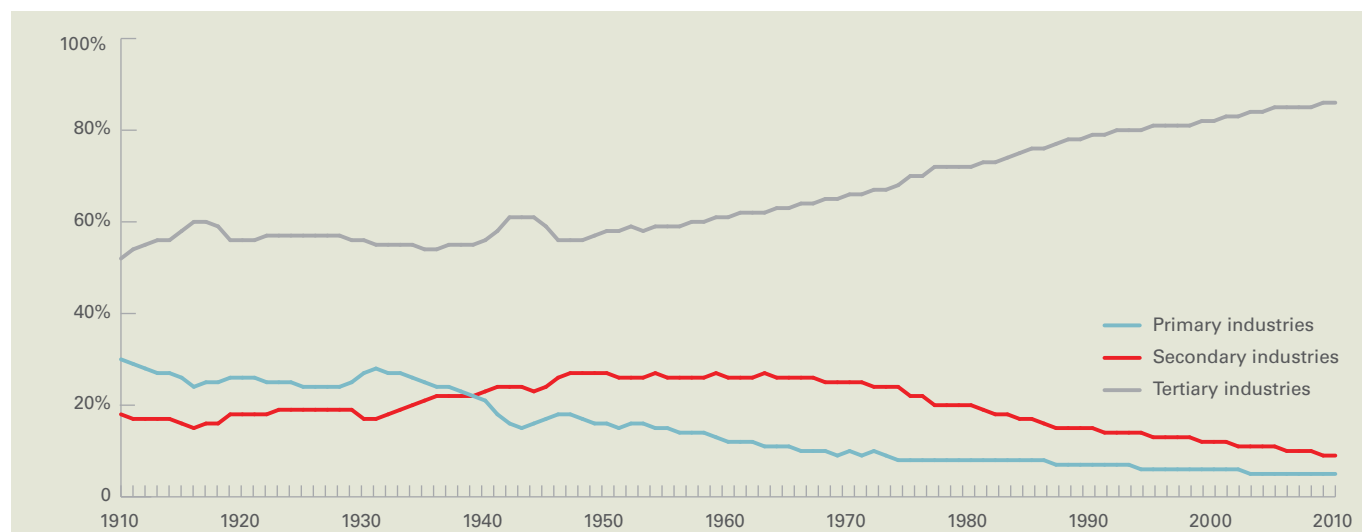
Understanding the role public transport plays in supporting the service industry should become synonymous with discussions on the role and future of Australia's service sector, especially its high value-add service sector and its importance to the national economy.

Figure 1: GDP by sector: Australia 1900 to 2040



Source: PwC analysis and forecasts using ABS, Butlin (1984) data, cited by Glenn Stevens (2012) "The Australian Economy: Some Perspective"
 Note: Break in time series data between 1940 and 1950

Figure 2: Employment by sector: Australia 1900 to 2010



Source: Ellis Connolly and Christine Lewis (2010) "Structural Change in the Australian Economy," Bulletin, September Quarter 2010, 1, online at: <http://www.rba.gov.au/publications/bulletin/2010/sep/1.html> (accessed 11 December 2013)

Recommendation:

1. Ensure that Australia's transport infrastructure aligns with, and supports, the structure and future competitiveness of our economy and its industries.

2.2 TRANSPORT REQUIREMENTS THROUGH THE STAGES OF DEVELOPMENT

A country, state or city's economic potential, comparative advantage and standard of living are related to how effectively transport supports the economy's industry structure.

An economy focused on primary product exports needs high-quality bulk rail and port infrastructure to transport primary products. The manufacturing sector relies heavily on road, rail and port infrastructure, typically centred on containerised freight. Where manufacturing is prominent in the industry mix, these supply chains are critical.

By contrast, an economy that is heavily driven by high value-add services requires connectivity between urban-based employees and firms. This is most efficiently delivered by mass public transport and aviation links.

Failure to meet these needs in a timely manner stifles economic potential, reducing competitiveness and suppressing standards of living. A country cannot move from a primary to manufacturing economy without the transport infrastructure to move manufactured goods to market. Similarly, if people are unable to connect in a services economy, the size of the market for the services will be smaller, firms will be less able to find employees that meet their needs, and employees will incur greater travel costs and have a smaller set of firms from which to obtain employment.

In the remainder of this section, we discuss the three stages of development and describe how appropriate transport infrastructure in each stage can increase Australia's productive capacity. We conclude by introducing the concept of public transport as the key component in the service sector supply chain.

2.2.1 Primary products

Primary products are bulky, typically transported in large quantities, often for export. An economy based on primary product exports, as Australia's was 100 years ago, needs bulk rail and port infrastructure to transport those primary products to places of processing or export.

Primary product transport was the driver behind many of Australia's first rail lines and the development of its ports. Rail lines constructed in the mid to late 1800s typically connected farming and mining communities with ports. For example, Australia's first rail line connected a coal mine in Newcastle with the port. Victoria's first rail lines were suburban, but these were soon followed by rail links connecting rural communities to the ports at Melbourne, Geelong and Portland. Western Australia's first railway was a timber railway, with rail lines to the ports of Bunbury, Esperance, Albany and Fremantle for the transport of grain and minerals constructed shortly after. The discovery of gold in towns such as Bendigo, Ballarat and Kalgoorlie led to the construction of railways to those areas and the development of Fremantle Port in 1897 was driven by gold discoveries in Western Australia.

Australia's early investments in rail and port infrastructure allowed agriculture to account for over 70 per cent of Australia's goods and services exports in the first half of the 1900s.¹¹ Mining was also important, comprising 8 per cent of Australian employment in 1900, and around 10 per cent of GDP (as compared to around 19 per cent of GDP in agriculture).¹²

The importance of these transport networks for primary production continues today, with the transport capacity of Australia's rail and ports a major determinant of how, where and when mineral extraction can occur or whether certain types of agricultural production are viable. The bulk ports of the Pilbara, Northern Queensland and Newcastle are vital to the export of iron ore and coal from these regions. All of these ports are served by major rail systems, with the capacity of these rail systems setting an upper limit on the amount of ore or coal that can be produced and exported. Australia also remains an important agricultural exporter.

The investment in resource supply chain infrastructure over the last decade is a prime example of investing in the transport required to support our country's emerging economic growth opportunities. This approach to investment in transport infrastructure needs to be carried forward as we examine our future economic prospects and emerging industry requirements.

11. Productivity Commission (2005), *Trends in Australian Agriculture*, Research Paper, Canberra, online at: http://www.pc.gov.au/data/assets/pdf_file/0018/8361/agriculture.pdf (accessed 24 December 2013) at p59

12. Robertson, Paul (2008) *Resource Based or Resource Cursed? A Brief (And Selective) History of the Australian Economy Since 1901*, Australian Innovation Research Centre Working Paper Series WP/0108, online at: http://www.utas.edu.au/data/assets/pdf_file/0003/111189/Resource-Based-or-Resource-Cursed.pdf (accessed 2 January 2014)



2.2.2 Manufacturing

As economies develop, many move through a phase of increased manufacture of physical goods. In Australia, the share of manufacturing employment increased from around 15 per cent in 1900 to over 25 per cent in the 1950s. This share has declined since 1970, with less than 10 per cent of the employed population now engaged in manufacturing. Manufacturing output has grown substantially during this period, increasing more than fourfold between the mid-1950s and 2000-01.¹³ However, other sectors have grown faster, reducing the manufacturing share, with capital substitution also decreasing manufacturing employment.

Manufacturing requires transport infrastructure for moving inputs to the places of manufacture and for transporting the final product to consumers. Improved transport infrastructure reduces costs for firms and prices for their customers and creates a larger market that enables more specialisation. Effective transport infrastructure also provides a driver for productivity improvements, as manufacturing firms face competition from other firms who are able to access the same markets despite being in distant locations.

The shape of the global manufacturing industry underwent a major change in the early 1950s with the development of containerised shipping. The shift to containerisation dramatically reduced transport costs, with the standardised containers removing the need for sorting of shipments and warehousing, and providing for more efficient port operation.

As a result, an economy that relies heavily on manufacturing needs road, rail and port infrastructure centred on containerised freight. These infrastructure networks are also critical to underpinning our retail supply chains. Containerised freight dominates the operations of Port Botany, the Port of Melbourne and the Port of Brisbane, with containerised freight also comprising the majority of Fremantle Port's operations.

2.2.3 Services

Australia is now a service economy, with over approximately 85 per cent of employment in the services sector. In a service economy, especially the high value-add service sector, the most important market is the labour market. As such, a service economy requires connectivity between employees and employers, supported by mass public transport and aviation links. Services activity is particularly concentrated in the centres of major cities, with the delivery of the services dependent on employees and customers being able to access those centres.

Even with near universal internet and phone connectivity, physically connecting people is vital in many service sectors. People learn more effectively from each other when they are face-to-face. Innovations flow more readily when people are able to connect directly, be that between fellow employees, firms at different points in the supply chain, or competitors and other innovators in the same industry. Ideas build on ideas.

The benefit of co-location is demonstrated by the massive concentration of technological companies in the small geographic area of Silicon Valley. Despite access to technologies that would appear to make the need for co-location obsolete, the benefits of employers and employees being able to physically access each other are so high that technological businesses and employees flock to this common area. It is these benefits of physical proximity that underpin the theory of agglomeration.

The net result of this need for co-location, with the most productive locations being dense economic clusters, is that a service economy needs effective transport to move people within and between these clusters. We discuss these clusters and the critical role of mass public transport in the service sector supply chain in the following chapter.

13. Productivity Commission (2003), *Trends in Australian Manufacturing*, Commission Research Paper, AusInfo, Canberra, online at: http://www.pc.gov.au/_data/assets/pdf_file/0005/8447/tiam.pdf (accessed 23 December 2013)

2.3 THE SERVICE SECTOR SUPPLY CHAIN

The importance of efficient supply chains is well recognised in the primary and manufacturing sectors. In the case of primary industries, many inputs and the primary product outputs are bulky and expensive to transport. The ability to get the primary output to markets is a core factor in the cost of production for the primary producer and the price ultimately paid by consumers.

In manufacturing, globalisation has been driven by the development and expansion of efficient supply chains, allowing manufactured goods and their inputs to be cheaply transported across the globe. Developments such as containerised shipping have allowed for manufacturing to be carried out in the lowest cost locations, with the supply chains delivering the manufactured goods to consumers who are often at a great distance from the point of manufacture.

For a service economy, an efficient supply chain is no less important. Here, an efficient supply chain transports large numbers of people to locations where they can provide and receive high-value services. Efficient mass transport is the key to moving people to places where their productivity can be maximised. The actual mode of this mass transit is less important and will differ by location. In some cases this may be bus networks utilising current road infrastructure. In other areas rail services provide the most efficient access. Some locations can be served by private vehicle (car) transport. However, given the location and employment density of high-value service sector locations (see Table 1), constraints like parking and congestion hinder the efficiency of this mode to underpin the required transport task. Across all of these examples, one thing holds true: inefficient transport stifles productivity.

An efficient service sector supply chain minimises the time and cost of transporting people from the widest area, maximising agglomeration effects on productivity. It increases the size of the market for workers. It increases the size of the market for outputs produced by the agglomerated service providers. Moreover, it effectively brings the produced services closer to the customer.

Inefficiencies in the service sector supply chain are often less salient to producers and customers than inefficiencies in primary product and manufacturing supply chains. In a typical primary or manufacturing sector firm, inefficiencies in the supply chain directly influence the costs of the firm and final price of the good. For a service sector firm, this may not be the case as the transport of their most important resource, their labour, is typically out of their control.

Accordingly, the costs of employees travelling outside of employment hours are not directly priced in the final service, yet they matter to those employees, potentially affecting their employment decisions and other productive activities. An inefficient service sector supply chain reduces the size of the market for employees, reduces the size of the market for the produced services, and constrains the flow of ideas between people, firms and competitors. In essence, while the impact is not immediately felt on the bottom line, the cumulative impact to business profitability and national productivity over a longer period can be substantial.

Imagine a scenario where an employee in the service industry had their commute time captured as part of their working day, implying the company or government agency they worked for had a direct incentive to provide access to labour markets in the most efficient manner. What would our transport system look like? What would be the expectations, optimisation, investment, and shared concerns for the functioning of the network? What would our cities and urban planning policies look like and how could location be used to gain a competitive advantage? How would transport services be priced to prioritise demand at key times? How would funding questions be answered and project financing be arranged?

These are the questions posed when the service sector supply chain is examined through the same lens, and with the same rigour, with which the supply chains that support the primary and secondary industries are examined. Upon reflecting on these questions with a range of industry stakeholders, the answers differ to what is being witnessed in current decisions.



Image courtesy of Transdev Australia

03 THE URBAN IMPERATIVE



THE URBAN IMPERATIVE

The changing structure of the Australian economy, and rising importance of the high-value service sector, not only shapes and changes the required investment in transport infrastructure, it also fundamentally alters our urban areas and elevates the importance of key economic clusters.

Simply, location matters. There is a small handful of key economic clusters which have a disproportionately large impact on the Australian economy. The productive growth of these clusters is underpinned by agglomeration and efficient access to labour markets. Hence, identifying these clusters

and ensuring that transport planning and investment drive this productive growth are of national economic significance.

This chapter builds upon past TTF research on the importance of CBD accessibility¹⁴ to demonstrate the growing importance of key economic clusters. It then shows how changes in these clusters are being supported by public transport, with a reliance on modes of transport not suited to meeting the needs of the high value-add service sector supply chain having the potential to stifle the productive capacity of these locations.

3.1 THE IMPORTANCE OF AUSTRALIA'S URBAN AREAS

Australia's urban centres are the major drivers of Australia's economic activity. This activity is predominantly in the services sector. Accordingly, any discussion on how to improve productivity in Australia, and in particular in Australia's services sector, must centre on urban areas and the CBDs of major cities.

Table 1: Australia's largest economies

TOP PERFORMING LOCATIONS BY GROSS OUTPUT (\$ MILLION) FY02			TOP PERFORMING LOCATIONS BY GROSS OUTPUT (\$ MILLION) FY13		
1	Sydney CBD	50,441	1	Sydney CBD	64,208
2	Melbourne CBD	34,684	2	Melbourne CBD	55,315
3	Roebourne (WA)	28,726	3	Perth CBD	28,461
4	Perth CBD	17,597	4	Roebourne (WA)	24,488
5	Brisbane CBD	15,657	5	Ashburton (WA)	24,353
6	Adelaide CBD	11,725	6	East Pilbara (WA)	24,168
7	North Sydney (NSW)	10,484	7	Brisbane CBD	23,395
8	Parramatta (NSW)	6,614	8	Adelaide CBD	16,136
9	Churchill (La Trobe Valley, Vic)	5,296	9	North Sydney (NSW)	10,928
10	Dandenong (Vic)	5,275	10	Macquarie Park (NSW)	9,113
11	St Leonards (NSW)	4,684	11	Parramatta (NSW)	7,610
12	Macquarie Park (NSW)	4,684	12	Dandenong (Vic)	7,162
13	Ashburton (WA)	4,541	13	Pymont – Ultimo (NSW)	7,065
14	Mascot – Eastlakes (NSW)	3,922	14	Broadsound – Nebo (Qld)	5,974
15	Broadsound – Nebo (Qld)	3,813	15	Civic (Canberra CBD)	5,555
16	Clayton (Vic)	3,611	16	St Leonards (NSW)	5,328
17	East Pilbara (WA)	3,584	17	Richmond (Vic)	5,306
18	Hobart CBD	3,568	18	Homebush Bay (NSW)	5,117
19	Chatswood (NSW)	3,557	19	Mascot – Eastlakes (NSW)	4,338
20	Rocklea - Acacia Ridge (Qld)	3,457	20	Surry Hills (NSW)	4,318
% of total Australian GDP from the top 10 regions		16.9%	% of total Australian GDP from the top 10 regions		18.4%
% of total Australian GDP from the top 20 regions		20.4%	% of total Australian GDP from the top 20 regions		22.2%

Source: PwC Geospatial Economic Model (GEM). Measured on an SA2 basis, with Melbourne CBD capturing Melbourne, Docklands and Southbank.

14. Tourism & Transport Forum and Booz & Co (2013) *Accessing our CBDs*, Sydney, online at: <http://www.ttf.org.au/Content/> (accessed 22 March 2014)

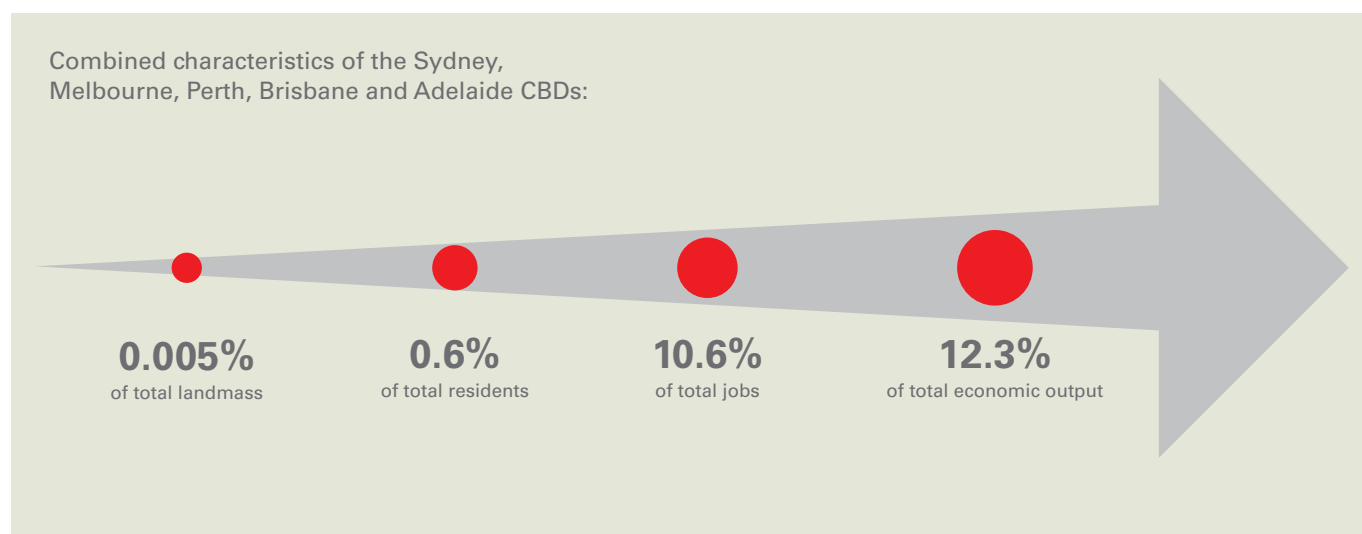
Table 1 reveals some key insights into the changing structure of Australia's economy. In particular, it highlights the importance of dense urban economic clusters of service sector employment. Sydney and Melbourne CBDs are the most obvious examples of this, together generating 7.9 per cent of Australia's economic output in 2013.¹⁵ These locations tower above any other locations in Australia in terms of economic importance. The smaller CBDs and other dense clusters of economic activity like North Sydney and Macquarie Park round out the top 10 locations. Expanding the analysis out to the top 20 largest economies in Australia reveals the emerging growth of more high-value service sector clusters – Homebush Bay (NSW), Pyrmont (NSW), Surry Hills (NSW), Richmond (Vic) and Civic in Canberra. It also mirrors the challenges being felt in the manufacturing sector during the resource boom, with locations like Dandenong and Mascot slipping down the list.

Focusing the analysis on the most critical urban clusters, we find that Australia's five largest urban areas (Sydney, Melbourne, Brisbane, Perth and Adelaide), generate 61.5 per cent of total economic output (Table 2). The CBDs within these capital cities alone generate 12.3 per cent of total economic output. Yet these areas employ 10.6 per cent of the population and house only 0.6 per cent of the residential population, highlighting the critical importance of access to, and between, these areas of national economic importance.

Figure 3 below summarises the disproportionate economic importance of Australia's five largest high value-add service sector clusters. These clusters are the CBDs in our five largest urban areas.



Figure 3: The five most important urban locations to the Australian economy



Source: PwC Geospatial Economic Model (GEM). Measured on a SA2 basis, with Melbourne CBD capturing Melbourne, Docklands and Southbank

15. PwC Geospatial Economic Model (GEM), as reported in PwC (2014) *Australia Uncovered*

Table 2: Gross output and residential population by location

GROSS OUTPUT BY LOCATION (\$ MILLION) FY13			RESIDENTIAL POPULATION FY13	
	LOCATION	URBAN AREA	CBD*	CBD*
1	Sydney	324,941	64,208	26,800
2	Melbourne	262,906	55,315	46,678
3	Perth	132,599	28,461	30,565
4	Brisbane	143,432	23,395	10,310
5	Adelaide	72,655	16,136	15,196
Total		936,534	187,515	129,549
% of Australian total GDP and resident populations from these regions		61.5%	12.3%	0.60%

Source: PwC Geospatial Economic Model (GEM), ABS. Measured on an ABS defined 'Urban Area' or SA2 basis, with Melbourne CBD capturing Melbourne, Docklands and Southbank

What's more, the importance of these locations is increasing. Economic activity has been concentrating in these locations over the past decade and with the decline in traditional manufacturing areas and the peaking of the mining resource investment boom, we expect this trend to accelerate. Cities, and the dense economic clusters within cities, will become increasingly important to our national economy.

This concentration of economic activity is both a risk and an opportunity. It poses a risk because inefficiencies in the functioning of these locations, be it through constrained access, regulatory burdens or poor governance, are of national significance. On the other hand, improving the functioning of these locations has the potential to unlock productive capacity and growth that is of national significance.

Recommendations:

- Identify the locations in Australia with the greatest current and future economic significance. Incorporate the understanding of these locations into the current:
 - Infrastructure Australia criteria for Nationally Significant infrastructure investment.
 - Identification and prioritisation of projects and policies in state-based infrastructure and transport strategies.
- As a priority, identify the critical high-value service sector clusters within cities to:
 - Assess these clusters' current linkages to appropriate labour markets.
 - Prioritise evidence-based solutions to existing and emerging transport capacity constraints which hinder the current performance and future growth of these key clusters.

Figure 4: Relationship between mass transit usage and job density, Sydney 2006



Source: Daniels, R and Mulley, C 2011, 'Exploring the role of public transport in agglomeration economies and centre', ATRF paper, reproduced in Major Cities Unit, 2012, 'State of Australian Cities 2012'

3.2 THE TRANSPORT REQUIREMENTS OF MAJOR URBAN AREAS



There is clear evidence of increasing demand for public transport supporting the broader structural changes in our economy, the evolution of our cities and the growth of these key economic clusters. However, much of this demand has been met by latent capacity in existing networks. This elevates the importance of ensuring emerging public transport capacity constraints around key clusters of economic activity are identified, with evidence-based solutions prioritised and incorporated into nationally significant infrastructure pipelines. The remainder of this chapter will discuss this evidence and the implications for investment in public transport required to underpin our future economic capacity.

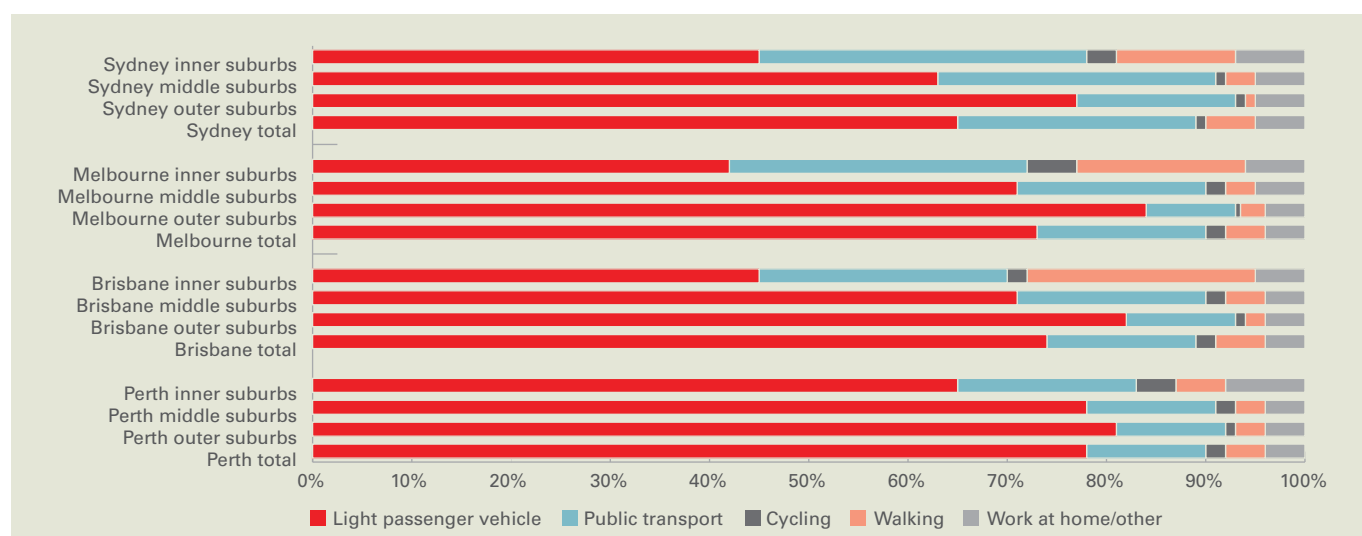
3.2.1 Demand for public transport

The importance of CBDs to economic activity is reflected in their high job density. Using Sydney as an example, the CBD has a density of over 500 jobs per hectare (Figure 4). That reduces to fewer than 400 for North Sydney, with job density declining rapidly as distance from the CBD increases. These densities have a strong relationship with the mode of transport to employment. High concentrations of jobs require strong people-moving links into and around tightly packed areas, with public transport being the dominant mode of transport in high job-density areas such as CBDs. In the Sydney CBD, around 70 per cent of journeys to work are undertaken by public transport. In North Sydney, more than 50 per cent use public transport to travel to work. As density of jobs rapidly decreases with distance from the CBD, so too does the proportion of workers travelling to work by public transport (Figure 4).

This pattern of higher public transport usage in the inner city is reflected in all four of Australia's major cities (Figure 5). Less than 50 per cent of commuters to Sydney, Melbourne or Brisbane's inner suburbs use private passenger vehicles. In all four cities, the proportion of travellers using public or active transport options such as walking declines with the move from inner to middle to outer suburbs.

The high level of public transport usage in the inner city reflects several factors. These areas are more connected to existing public transport networks than other areas of the city. They are relatively close to major trip attractors (work and leisure). There is limited parking availability and high prices for the available parking. High levels of road congestion in those areas also induce people to use public or active transport options and reduce the incentive to use or even own a car across Australia's urban areas. The following sections discuss these trends.

Figure 5: Mode of travel to work for commuters on Australia's four largest cities



Source: Major Cities Unit (2013) State of Australian Cities 2013, Department of Infrastructure and Transport, Canberra

3.2.2 Plateauing of private vehicle demand in Australia's capital cities

Individual demand for private vehicle use within Australia's capital cities has plateaued and started to decline. This is shown over the last ten years through the falling levels of annual private vehicle kilometres travelled per person (Figure 6).

While the individual's demand for car use within our capital cities is on a downward trend, total car kilometres travelled across the city have not declined due to growing population. This indicates that while car travel is becoming increasingly unattractive or unable to meet travel or lifestyle requirements, continued pressure will remain on our urban road networks.

The reduction in kilometres driven per person is also reflected in a peak in the modal share of urban passenger transport for cars, with a decline in the share for cars also occurring over the last ten years (Figure 7).

The decline in car use is largely driven by road congestion in urban areas as well as the inability of the car to provide efficient mass access to dense urban economies. The confined geography and high employment densities of the key economic clusters imply that there is neither the space (road space or parking space) nor capacity for private vehicles to efficiently support the transport requirements of these key locations. Mass transportation provided through bus networks or rail systems, and most likely a combination of both, overcomes these challenges through moving larger numbers of employees into geographically concentrated and confined areas.

This situation is a clear example of where different modes of transport support different economic and social requirements. While private vehicle travel is an incredibly important component of our transport network and supports specific industry and lifestyle requirements, mass public transport (or intermodal) solutions are required to support the productive growth of the high value-add service sector economy.

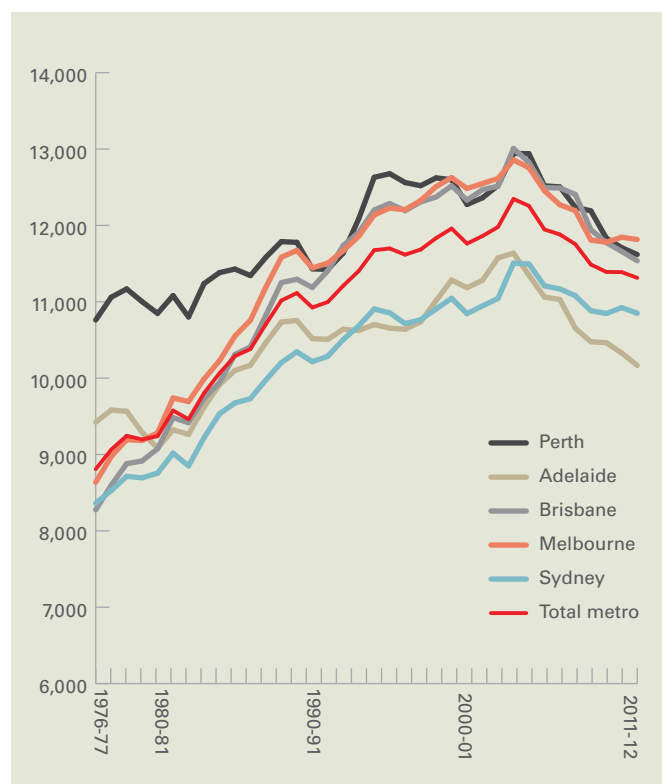
3.2.3 The shift to public transport

The shift from cars to public transport over the last decade has continued a strong trend of an increasing metropolitan passenger task for mass public transit in Australia (Figure 8). This has particularly been the case for heavy rail use, which has more than doubled since 1980. The current level of use of bus and heavy rail has markedly exceeded the post-war peaks that occurred before cars were the predominant mode of urban transport and for which the current transport systems' capacity were designed. Only light rail and tram use has remained below those post-war peaks.

3.2.4 The growth of the inner city

Inner city locations are becoming increasingly attractive as places of residence. The population in Australia's inner city local government areas has surged over the last decade. Growth between 2001 and 2011 ranged from 28 per cent for the Brisbane City Council (which encompasses close to half

Figure 6: Annual private vehicle kilometres per person



Sources: ABS, 2013, Regional Population Growth, Australia, catalogue number 3218.0; BITRE, 2013, Australian infrastructure statistics yearbook, Table T 3.3; PwC calculations

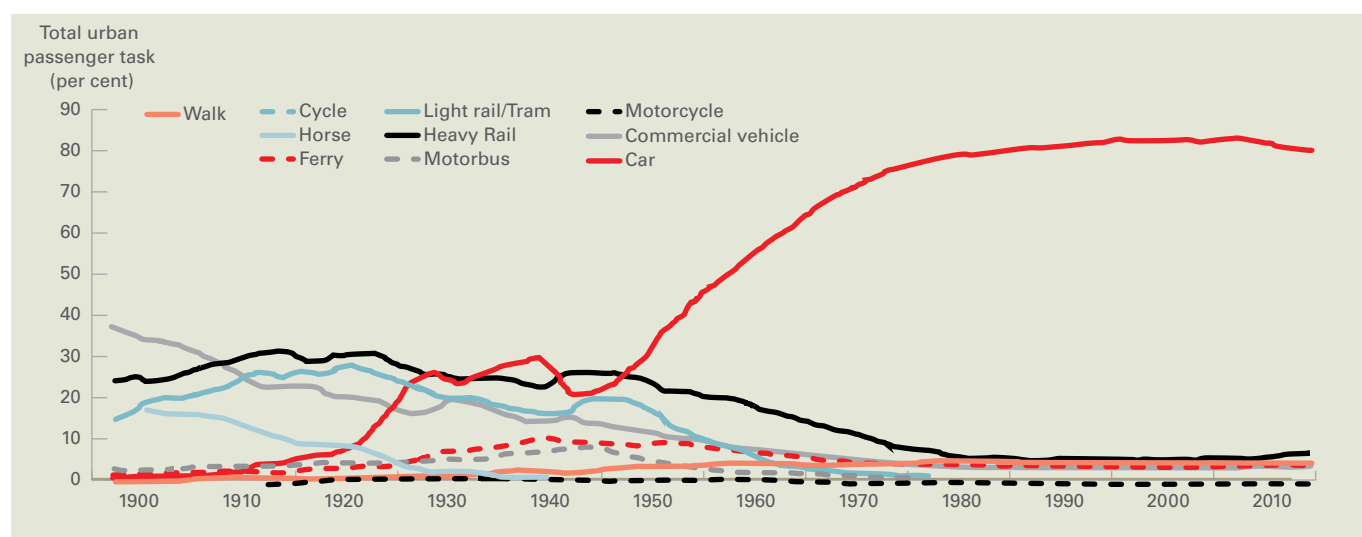
of the Brisbane metropolitan area), to 85 per cent for the City of Melbourne and 144 per cent for the City of Perth (Table 3). These growth rates are substantially higher than the Australian population growth of 21 per cent over that same period.

The increasing density of these knowledge workers residing in the inner city has several implications for transport infrastructure. First, inner city residents predominantly use public or active transport, and are significantly less likely to own cars. This will continue to boost demand for public and active transport, and will continue the trend of reduced private vehicle kilometres travelled per person.

Second, increasing density improves the economics of public transport. Australia's capital cities have some of the lower levels of cost recovery in the world for public transport, at around 25 per cent to 45 per cent across the five major capital cities. This resulted in a subsidy of \$3.3 billion out of \$5.2 billion in operating costs in 2008-09.¹⁶ However, one of the reasons for this low level of recovery is the low population density of the cities, which reduces the population size in the public transport catchment area. As density in the inner city increases, they will fall within existing public transport catchments and provide a basis for improved cost recovery in those areas.

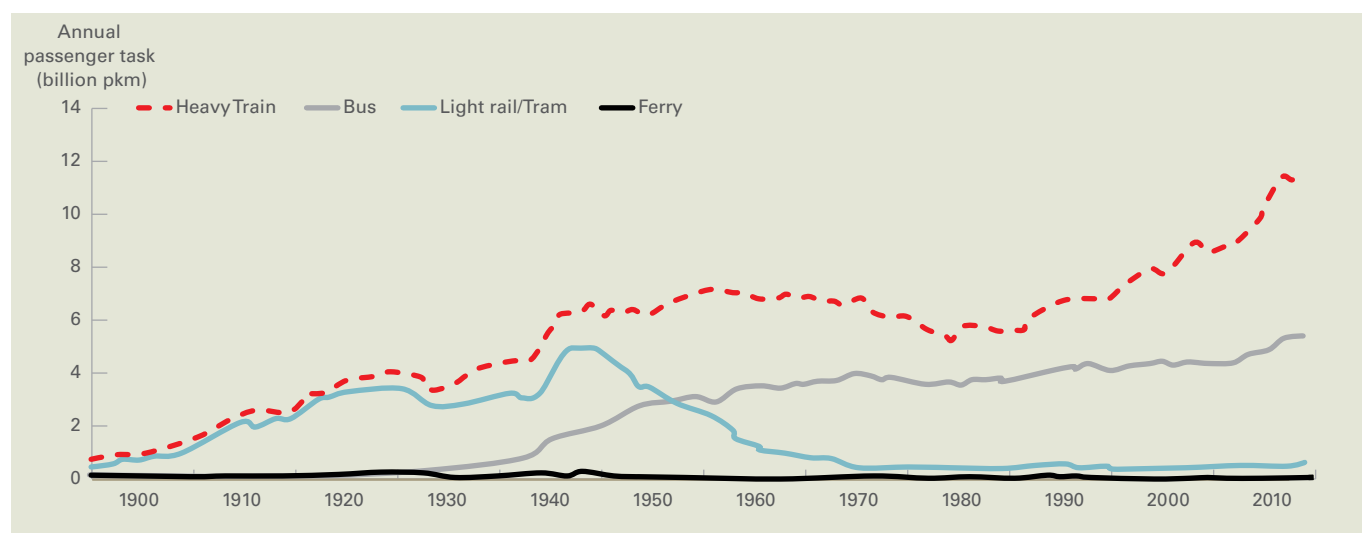
16. Tourism & Transport Forum and LEK Consulting (2011) *Meeting the Funding Challenges of Public Transport*, Sydney, online at: <http://www.ttf.org.au/Content/ptfundingchallenges0910.aspx> (accessed 2 January 2014)

Figure 7: Modal share for urban passenger transport 1900-2011



Source: Major Cities Unit (2012) State of Australian Cities 2012, Department of Infrastructure and Transport, Canberra, based on Cosgrove, D, (2011) 'Long-term patterns of Australian public transport use', Australian Transport Research Forum 2011 Proceedings, Adelaide

Figure 8: Total metropolitan passenger task performed by Australian mass transit modes 1900-2011



Source: Major Cities Unit (2012) State of Australian Cities 2012, Department of Infrastructure and Transport, Canberra, based on Cosgrove, D, (2011) 'Long-term patterns of Australian public transport use', Australian Transport Research Forum 2011 Proceedings, Adelaide

Table 3: Demographic change in the city

	WORKING POPULATION ¹⁷		WORKING POPULATION GROWTH (2001 TO 2011)	PROPORTION PROFESSIONAL OR MANAGERIAL (2011)	PROPORTION UNIVERSITY EDUCATION (2011)
CBD	2001	2011			
Sydney LGA	69,272	102,357	48%	56%	33%
Melbourne LGA	31,183	57,616	85%	57%	50%
Brisbane LGA	422,883	541,555	28%	42%	25%
Perth LGA	5,047	12,317	144%	57%	31%
Adelaide LGA	7,914	11,312	43%	54%	56%
Australia	8,298,606	10,058,325	21%	34%	14.3%

Source: ABS (2012) 2011 Census of Population and Housing – Time Series Profile, various; ABS (2012) 2011 Census Quickstats, various

17. By place of enumeration (i.e. where they were when they completed the Census)



WHEN HOUSING PRICES ARE HIGH, IT IS LARGELY BECAUSE LAND PRICES ARE HIGH. AND, LAND PRICES ARE HIGH WHEN THERE IS A 'SHORTAGE' OF WELL-LOCATED LAND. WE CANNOT DO MUCH ABOUT THE PHYSICAL SUPPLY OF LAND, BUT INVESTMENT IN TRANSPORTATION INFRASTRUCTURE – BY MAKING IT EASIER TO MOVE AROUND THE CITY – CAN INCREASE THE SUPPLY OF 'WELL-LOCATED' LAND. AND WHEN SUPPLY INCREASES, PRICES ADJUST. THIS MEANS THAT UNDERINVESTMENT IN TRANSPORTATION NETWORKS TENDS TO PUT UPWARD PRESSURE ON HOUSING COSTS.

DEPUTY GOVERNOR OF THE RESERVE BANK OF AUSTRALIA, PHILIP LOWE¹⁸

3.2.5 The scarcity of land

Improved transport infrastructure increases the supply of well-located land, reducing its cost. Where land is an input to many goods and services, reducing the cost of the land input improves the productivity of the firm that uses it. As such, there is potential for productivity gains where areas of cheaper land are effectively connected to space-starved CBDs. The connected areas effectively move closer to the

CBD, providing places for employees to live where they can still access their place of work with a reasonable commute. Alternatively, connecting new areas provides an opportunity for businesses to locate outside of the CBD but to still retain connection to the centres of economic activity (for example, see our analysis of the economic impact of the Epping to Chatswood Rail Link in section 4.1).

18. Lowe, Philip (2013), *Speech to the IARIW-UNSW Conference on Productivity Measurement, Drivers and Trends*, Sydney - 26 November 2013, online at: <http://www.rba.gov.au/speeches/2013/sp-dg-261113.html#f7> (accessed 2 January 2014)

04 THE ECONOMIC RETURN ON PUBLIC TRANSPORT INVESTMENT



THE ECONOMIC RETURN ON PUBLIC TRANSPORT INVESTMENT

The preceding chapters explain why public transport is critical to unlocking the productive capacity of our economy and major urban areas. The remainder of the report examines the changes to employment, business profitability, tax revenues and the economy delivered by public transport investment.

The lack of *ex-post* analysis on the impacts of public transport on the productive capacity of a location makes answering this question challenging. Most work to date has focused on the theoretical analysis, or simulated modelling of, potential agglomeration benefits and other wider benefits of projects that have yet to be committed to, or delivered.

While this analysis can be informative, there is a pressing need to move beyond this theory to examine what the actual 'on-the-ground' observable and quantifiable impacts are on employment, businesses, and government tax revenue. Such work based on actual observation is required to validate these theoretical studies and, more importantly, underpin more holistic and rigorous transport policy and investment decisions.

The lack of *ex-post* analysis is partly due to the lack of granular economic data required to measure and quantify the changes in locations attributable to public transport investment. This has been overcome through the use of the PwC Geospatial Economic Model (GEM) which quantifies the economic output from 2,214 areas in Australia from 2001 through to 2013 in a manner consistent and reconcilable with Australian Bureau of Statistics (ABS) measures of GDP and Gross State Product (GSP).¹⁹

In this chapter, GEM is used to understand the changes to the local economies associated with the opening of the Epping to Chatswood Rail Link in Sydney in 2009. Findings from this *ex-post* case study are then compared and benchmarked with other international and domestic *ex-post* case studies on the impact that public transport investment has on the productive capacity of locations.

This work finds that expanding access to labour markets through the introduction of public transport delivers a significant economic dividend to specific locations. Macquarie Park is the most notable of these locations, with the opening of the rail line in 2009 accelerating what was already strong growth in both employment and economic output.

The Macquarie Park economy grew by an additional 1.56 to 2.44 per cent per annum upon the opening of the rail line when other locational, industry, and macroeconomic drivers were controlled for. Increased business profitability, followed by rising wages and tax revenues to governments, drove this growth.

These findings, compared alongside case studies of the City Loop Line in Melbourne and rail investment in London, shows that the return from public transport investment is dependent upon a number of factors. These factors include:

- The current level of public transport accessibility to a location, in terms of both access and capacity constraints.
- The differing sizes and nature of locations which are being linked or having their accessibility improved. This is important as there is a suggested flow of jobs and economic activity from smaller economies to larger, more productive economies once public transport connectivity is improved.
- The nature of employment and industries within the location. The case studies show that high value-add service industries deliver the greatest benefits.
- The maturity and characteristics of a location. For example, a low density and low value area of economic activity vs. a relatively contained business park vs. an established high density economic cluster display different growth patterns and potential with changes in public transport accessibility.

19. See Appendix A for details on GEM

4.1 ECONOMIC RETURNS FROM THE EPPING TO CHATSWOOD RAIL LINK

The primary analysis identifies the impact of the opening of the Epping to Chatswood Rail Link on the economic performance of Epping, Macquarie Park, North Ryde and Chatswood.

The key milestones on project delivery include:

- **1998:** Parramatta to Chatswood (Parramatta Rail Link) announced.
- **November 2002:** construction commenced.
- **August 2003:** Epping to Parramatta section postponed indefinitely. Epping to Chatswood section (Epping to Chatswood Rail Link) still to be completed.
- **February 2009:** Operations commence.

Understanding the changes in economies along the rail line needs to be done within the context of the broader NSW economy.

Table 4 below shows the largest economies in NSW and how they have changed since 2002. Most notable has been the growth of Macquarie Park, with the size of its economy more than doubling in real terms as it has moved up to the third largest economy in NSW (and 10th largest in Australia). Also notable is North Sydney, whose economy has stagnated over the same period. Should recent growth trends in both locations continue, Macquarie Park could shortly become NSW's second largest economy (and Australia's 9th largest economy).

Efficiently expanding Macquarie Park's access to labour markets through the introduction of public transport was just one of a number of factors driving the growth. Other critical factors included the success of local planning policies, the nature of opportunity offered to business by Macquarie Park, and its location with respect to other economic clusters in Sydney. The following analysis shows that the introduction of public transport to expand access to labour markets accelerated and enhanced the already strong growth in the area.

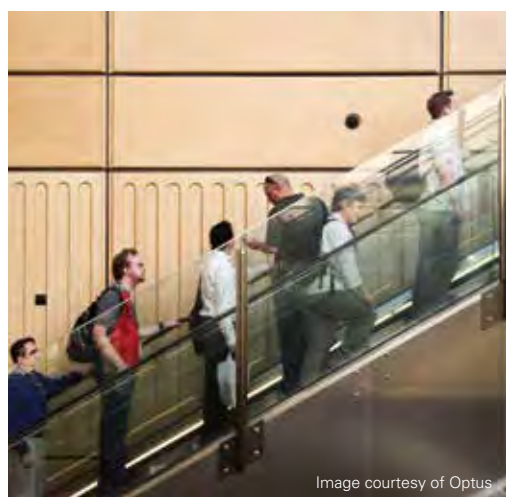


Image courtesy of Optus



Table 4: NSW's largest economies

TOP PERFORMING LOCATIONS BY GROSS OUTPUT (\$ MILLION) FY02		
1	Sydney – Haymarket – The Rocks	50,441
2	North Sydney – Lavender Bay	10,484
3	Parramatta – Rosehill	6,614
4	St Leonards – Naremburn	4,684
5	Macquarie Park – Marsfield	4,684
6	Mascot – Eastlakes	3,922
7	Chatswood (East) – Artarmon	3,557
8	Erskineville – Alexandria	3,358
9	Pyrmont – Ultimo	2,932
10	Surry Hills	2,867

TOP PERFORMING LOCATIONS BY GROSS OUTPUT (\$ MILLION) FY13		
1	Sydney – Haymarket – The Rocks	64,208
2	North Sydney – Lavender Bay	10,928
3	Macquarie Park – Marsfield	9,113
4	Parramatta – Rosehill	7,610
5	Pyrmont – Ultimo	7,065
6	St Leonards – Naremburn	5,328
7	Homebush Bay – Silverwater	5,117
8	Mascot – Eastlakes	4,338
9	Surry Hills	4,318
10	Chatswood (East) – Artarmon	4,166

Source: PwC, Geospatial Economic Model



Image courtesy of City of Ryde

4.1.1 Methodology

The impact of the opening of the rail line has been estimated by looking at the compound annual growth rates (CAGR) of the economy and employment prior to the opening and comparing these to post-opening growth rates.

These rates were normalised to control for industry, locational and broader macroeconomic variables which influence economic growth in Australia. The impact of opening the rail line on the area is shown as a range, reflecting the different levels at which variables could be controlled for (either at a Sydney, NSW or national level).

The dataset underpinning the analysis is drawn from PwC's GEM.²⁰ This data allows analysis of small clusters of economic activity by detailing traditional economic outputs and productivity metrics like gross output and jobs, as well as measures of industry density and industry productivity. It also provides estimates of tax revenues generated in these economic clusters.

4.1.2 Changes at Macquarie Park

Macquarie Park was one of the fastest growing economies prior to the opening of the Epping to Chatswood Rail Link. Part of this is due to movement and decisions made by firms upon commencement of construction to locate to the area. Upon opening of the rail line, the growth in Macquarie Park accelerated further, bucking the broader national and NSW trends of weak economic growth and contracting employment across this period.

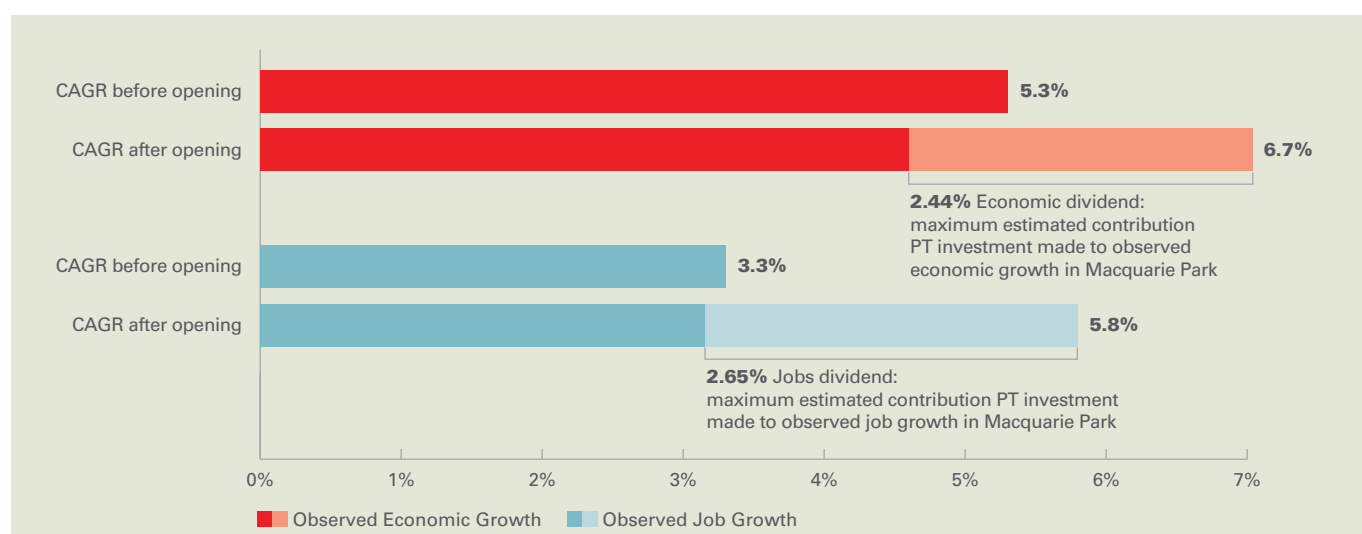
Figure 9 below demonstrates this growth. In the years prior to the commencement of services (2001-2008), the CAGR of economic activity²¹ was a very robust 5.3 per cent. After commencement of services (2009-2013), Macquarie Park recorded an observed CAGR of 6.7 per cent. Between an estimated 1.56 per cent to 2.44 per cent of this total growth was influenced by the improvement in accessibility to labour markets due to new rail services.

Employment growth post-opening was even stronger, with an estimated additional growth in jobs of between 2.19 per cent to 2.65 per cent per annum. In aggregate, this implies the size of the workforce in Macquarie Park and its surrounding precincts is estimated to have increased by 32.5 per cent since the opening of the line. This finding is unsurprising given the importance of access to labour markets for the high value-add jobs (as discussed in previous sections) found in Macquarie Park, and the role the rail line played in significantly expanding this access.

4.1.3 Examining the PT-related growth in Macquarie Park

The next section explores some of the characteristics of growth seen in Macquarie Park and the impact the opening of the rail line had on this growth.

Figure 9: Estimated economic and job dividend to Macquarie Park post the opening of rail line in 2009

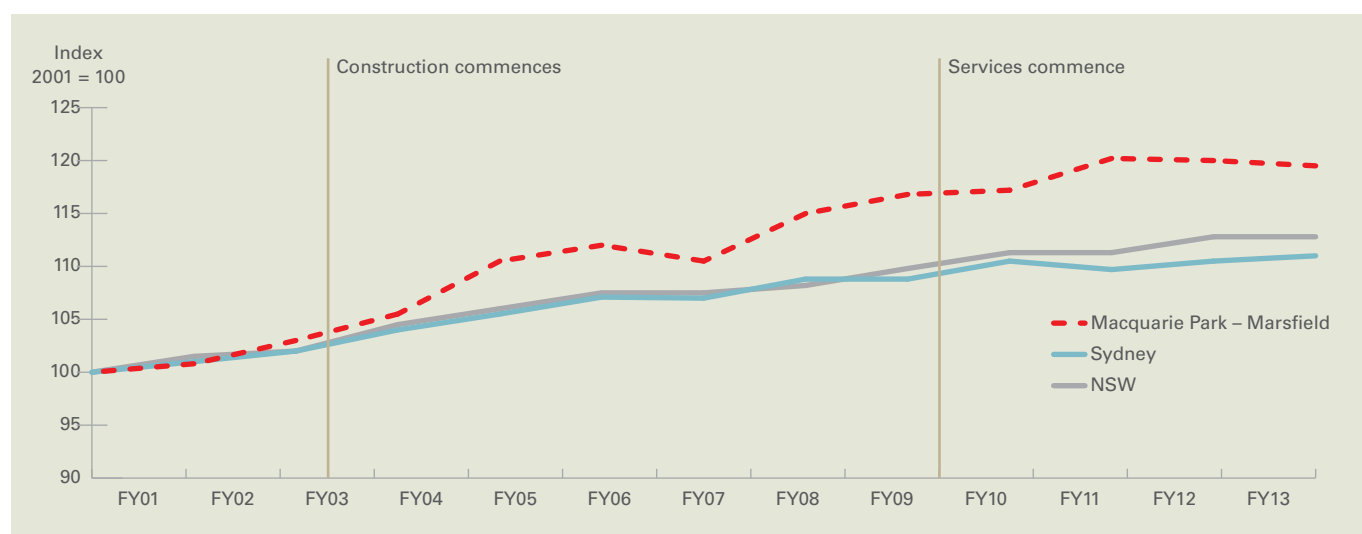


Source: PwC, Geospatial Economic Model (GEM). Note: CAGR before opening reflects annual growth from 2001-2008. CAGR after opening reflects annual growth 2008-2013. The estimated dividend shown on this chart reflects the maximum value

20. See Appendix A for details on GEM

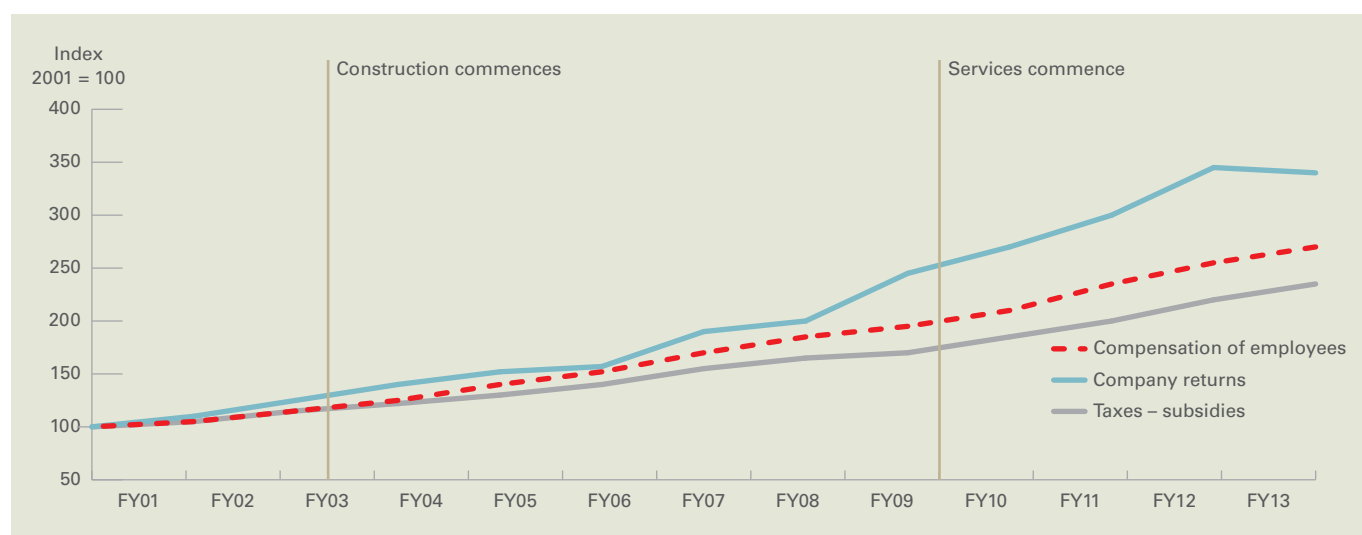
21. Economic activity equates to Gross Small Area Product, which is measured in a consistent and reconcilable manner with the ABS income method for calculating Gross Domestic Product (GDP) and Gross State Product (GSP)

Figure 10: Economic output per employee



Source: PwC, Geospatial Economic Model (GEM)

Figure 11: Drivers of economic growth in Macquarie Park



Source: PwC, Geospatial Economic Model (GEM)

Productive growth

Economic growth is most sustainable when it is matched by increasing levels of productivity – i.e. the labour and capital invested within the location delivers higher returns.

In a similar manner to the sustained growth in economic activity and employment opportunities seen after opening the rail line, there is also a sustained increase in the economic output per worker. However, this growth has flattened in the past two years as employment growth has outstripped the economic growth of the area. Interestingly, it is also possible to see the accelerating growth in output per worker begin to deviate from Sydney and NSW trend after construction commenced (2002/03) – a signalling to business that mass public transport capacity was going to be delivered and hence could be factored into decisions around investment, location and workforce.

Business profitability

Businesses in Macquarie Park and its surrounding precincts have been the prime beneficiaries of the rail line. While employment growth has been strong and wages have grown,²² businesses have realised the greatest returns to their investments and operations in the area.²³ Accompanying this growth in business profitability has been the estimated increase in taxes²⁴ generated by the Macquarie Park economy. These drivers of economic growth are shown above in Figure 11.

When examining business profitability, the most notable feature is a slight acceleration in growth upon commencement of construction, followed by a rapid acceleration of growth post opening of the rail line. This mirrors the trends seen when examining output per worker. These sustained strong rates of growth far surpass levels seen elsewhere in Sydney or the NSW economy.

22. As technically measured by Compensation of Employees (COE)

23. As technically measured by Gross Operating Surplus and Mixed Income (GOSMI)

24. As technically measured by taxes on Product and Production minus subsidies

Table 5: Economic and transport characteristics of the Epping to Chatswood Rail Link

AREA (SA2)	SIZE OF ECONOMY FY 13 (\$B)	PT ACCESS PRIOR TO OPENING	AREA TRANSPORT CHARACTERISTIC	ESTIMATED CHANGE IN CAGR OF THE AREA POST OPENING OF THE RAIL LINE	
				ECONOMIC GROWTH	JOB GROWTH
Macquarie Park	\$8,851	Poor	Limited bus and no rail access	1.56% to 2.44%	2.19% to 2.65%
North Ryde	\$2,463	Moderate	Bus access but no rail access	-0.78% to 0.10%	-1.16% to -0.70%
Epping	\$1,037	Good	On an existing rail line with feeder buses	-1.61% to -0.73%	-2.20% to -1.74%
Chatswood	\$4,145	Good	On an existing rail line with feeder buses	-0.09% to 0.78%	0.55% to 1.00%

Source: PwC, Geospatial Economic Model, 2014. Range for economic and job growth reflects the differences when controlling for different industry, locational and broader macroeconomic variables

4.1.4 Changes along the rail corridor

Beyond Macquarie Park, the opening of the rail line influenced the economic profile of all station locations. The table above shows the changes in these characteristics, detailing the size of the local economy, transport characteristics and most importantly, the impact that the opening of the rail line had on the economies surrounding these stations.

Considering all locations on the rail line shows a different picture. While Macquarie Park, the largest and fastest growing of the local economies benefitted, the economic output and number of jobs in the two smallest economies, North Ryde and Epping, are estimated to have contracted in the years following the opening of the rail line.

The broader theories of agglomeration and labour market dynamics imply a likely transfer of output from these smaller locations to these larger locations. Critically, this transferred activity should become more productive due to the efficiencies and knowledge spill-overs found in these larger clusters. This implies economic growth stemming from the transfer, as opposed to simple redistribution of activity. Similarly, improving access to these more productive locations should result in people having greater employment and remuneration opportunities, hence a shift in the location and productivity of jobs along the corridor.

In the case of these four locations, the growth of Macquarie Park more than offsets the small declines elsewhere on the line. It is, however, important to consider the potential for broader transfers across the wider urban environment. While outside the scope of this specific piece of work to answer these wider transfer questions, it is interesting to consider North Sydney, which has experienced virtually no economic growth since 2001, alongside the phenomenal economic growth of Macquarie Park. Given the known relocation of major companies out of North Sydney to Macquarie Park, understanding not only the potential for redistribution of activity, but the actual efficiency or productivity of this activity at different locations should be a core focus of future work.

4.1.5 Transport's return on investment

Measuring the specific return on investment from the rail line can be approximated through examination of the normalised pre- and post-growth rates of Macquarie Park and its surrounding precincts. Since 2009, this difference equates to a present value of between \$1.02 billion and \$1.49 billion in additional economic activity for the area which can be attributed to the opening of the rail line.²⁵ This is a substantial return when considering the relatively short time in operation and that the initial capital investment required was an estimated \$2.3 billion.²⁶ This economic return has been shared between businesses, increased compensation to employees and greater tax revenue.

Importantly, the findings from this macroeconomic return on investment are not directly comparable or additive to the theory of cost-benefit analysis. Rather, these findings complement cost-benefit analysis by helping to identify and understand which types of transport infrastructure investments could lead to the greatest increase in the productive capacity of the Australian economy.

When considering the economic returns on investment from transport infrastructure, one of the simplest ways to stifle business profitability, employee wellbeing, economic growth, and our nation's productive capacity is to invest in the wrong projects, at the wrong time, for the wrong reasons. Even if a transport investment is aimed at meeting our economy's future requirements, failing to first explore all regulatory, governance or operational solutions, correctly specify the project outcomes, optimise delivery or prioritise correctly within a portfolio of potential investments can lead to a suboptimal use of resources.

25. *Ex-post* appraisal of economic benefits undertaken using the following parameters: base year - 2001 (date of last update for the Parramatta to Chatswood Economic and Financial Evaluation). Real economic discount rate – 7.0 per cent. The results reflect the range of economic growth that is estimated to stem from opening the rail line, after normalising for other economic, industry and locational variances

26. *Sydney Morning Herald*, Epping to Chatswood Rail Link opens, February 23, 2003. It is assumed the quoted cost is real, \$2009



4.1.6 Broader considerations

Continued monitoring of the rail corridor and Macquarie Park economy is needed over a much longer period to understand the full impacts of public transport investment on the productive capacity of the location. This will help inform a number of longer-term questions, pertinent to all major urban areas in Australia, that this *ex-post* study raises:

- Has the introduction of public transport simply accelerated the speed at which Macquarie Park reached its productive potential (based on industry mix and access to labour markets) or has it laid a foundation for continued strong growth and structural change in years to come?
- If public transport access to the location becomes constrained in future years, either through over-crowding due to excess demand or changes to timetables and service frequencies, will a commensurate decrease in these key economic metrics be witnessed? More broadly, how are current and emerging capacity constraints to accessing major urban centres around Australia likely to stifle or suppress the productive capacity of these nationally significant areas? What would the boost to the economy and living standards look like if these constraints were alleviated?
- How do critical nuances in industry composition and location across major urban areas influence the returns these industries are set to gain from investment in public transport?
- How can government and business use these 'on the ground findings' to help identify and prioritise investment in other locations where public transport has the capacity to unlock the same significant growth potential witnessed in Macquarie Park?

Recommendations:

4. Maximise the productive capacity of existing public transport infrastructure assets by exploring and testing all governance, regulatory or operating changes that could lead to the more efficient and effective use of this asset base.
5. Ensure all decisions on transport investment by both federal and state governments are underpinned by rigorous, transparent cost-benefit analysis. Federal transport funding should be modally-neutral and support both road and public transport infrastructure projects based on the outcomes of cost-benefit analysis and the needs of the modern economy.
6. Undertake and publish *ex-post* analysis on completed investments at five and then fifteen-year intervals. Use this local information to refine Australian transport appraisal.

4.2 INTERNATIONAL AND DOMESTIC CASE STUDIES

International and domestic studies illustrate the productivity effects of transport infrastructure on economic activity. In this section, we provide two case studies in which new transport infrastructure changed the economic dynamics in the area in which transport access was improved. The case studies are of:

- The regeneration of East London following construction of the Jubilee Line Extension and the Docklands Light Rail.
- The economic impact of the Melbourne City Loop.

These case studies support the observations that public transport investments hold significant ability to unlock, and then support the productive capacity of a location.

These studies also support the observation that the nature, magnitude, and speed of this support will differ depending on locational nuances.

Hence, these additional examples support the need for a better understanding of the granular structure and changes in locations to maximise the ability of public transport investment to unlock their productive capacity.

4.2.1 Regenerating East London

Canary Wharf was one of the world's busiest docks in the 1800s and was heralded as one of England's greatest civil engineering structures of its day. The decline of the port industry in the 1960s led to unemployment and social deprivation in the Docklands area. By 1980, the Docklands area was severely neglected and all the docks were closed by 1981.

In 1981, the London Docklands Development Corporation (LDDC) was established to redevelop the Docklands area. LDDC identified the need to improve public transport accessibility to the Docklands area early on in the planning stages of regeneration for the Isle of Dogs. On 7 October 1982, LDDC received government approval for the new Light Rail Transport system (LRT) and was further supported with a Private Bill introduced to the House of Commons before the end of the year. The LRT was viewed as a critical component in attracting new businesses, jobs, housing and people to the area. As such, the LDDC considered the announcement of the LRT to be a confirmation of the government's 'total commitment' to develop the area.²⁷ This was the beginning of the Docklands Light Rail and the London Underground's Jubilee Line Extension.

Public transport connectivity

The intention for the Docklands Light Rail (DLR) system was for it to be run as a highly efficient, reliable and comfortable service between areas of London. As such, the DLR system was designed to operate short trains on standard tracks and run frequently to support easy access to the area.²⁸ With this in mind, the first DLR routes, which connected Tower Gateway, Poplar, Island Gardens and Stratford, opened in 1987.²⁹ Extensions were subsequently built to Bank Station (City) in 1991, Beckton in 1994, Lewisham (south of Thames) in 1999, London City Airport in 2005, Woolwich Arsenal in 2009 and Stratford International in 2011.

Each extension proved to be a valuable link to support the regeneration of the Docklands area. For example, the Bank extension enabled the Docklands to have a direct line to the London Underground, which today links two financial districts in London. Similarly, the extension from Canary Wharf to Lewisham was to cut rail journey times from Lewisham from 39 to 16 minutes, allowing that an extra half-million people living south of the River Thames will be within 45 minutes of Canary Wharf.³⁰

In 1999, London Underground's Jubilee Line Extension (JLE), which runs between Green Park and Stratford, was opened. This extended the Jubilee Line, opened in 1979, which originally linked Stanmore and Charing Cross. Development in the Isle of Dogs was strongly boosted by the Department of Transport's approval of an extension of the Jubilee Line.

The extension was built to assist the regeneration of East London, including Docklands. It was also designed to ease DLR capacity restrictions and remove poor transport connectivity as a barrier to regeneration.³¹

The JLE improved East London's public transport connectivity to other parts of London. Most areas of West London that were more than 60 minutes away by public transport before the construction of the JLE are now within 60 minutes of North Greenwich.³²

27. London Docklands Development Corporation, *Rapid Rail System for Docklands Approved*, 7 October 1982, <http://www.lddc-history.org.uk/pressreleases/dlr/PR071082.pdf>, accessed 13 June 2014

28. Ibid

29. Transport for London, *DLR history timeline*, <http://www.tfl.gov.uk/corporate/modesoftransport/dlr/history/2982.aspx>, accessed 27 December 2013

30. London Docklands Development Corporation, *Lewisham Extension "Excellent News" for London Docklands*, 22 November 1990, <http://www.lddc-history.org.uk/pressreleases/dlr/PR221190.pdf>, accessed 13 June 2014

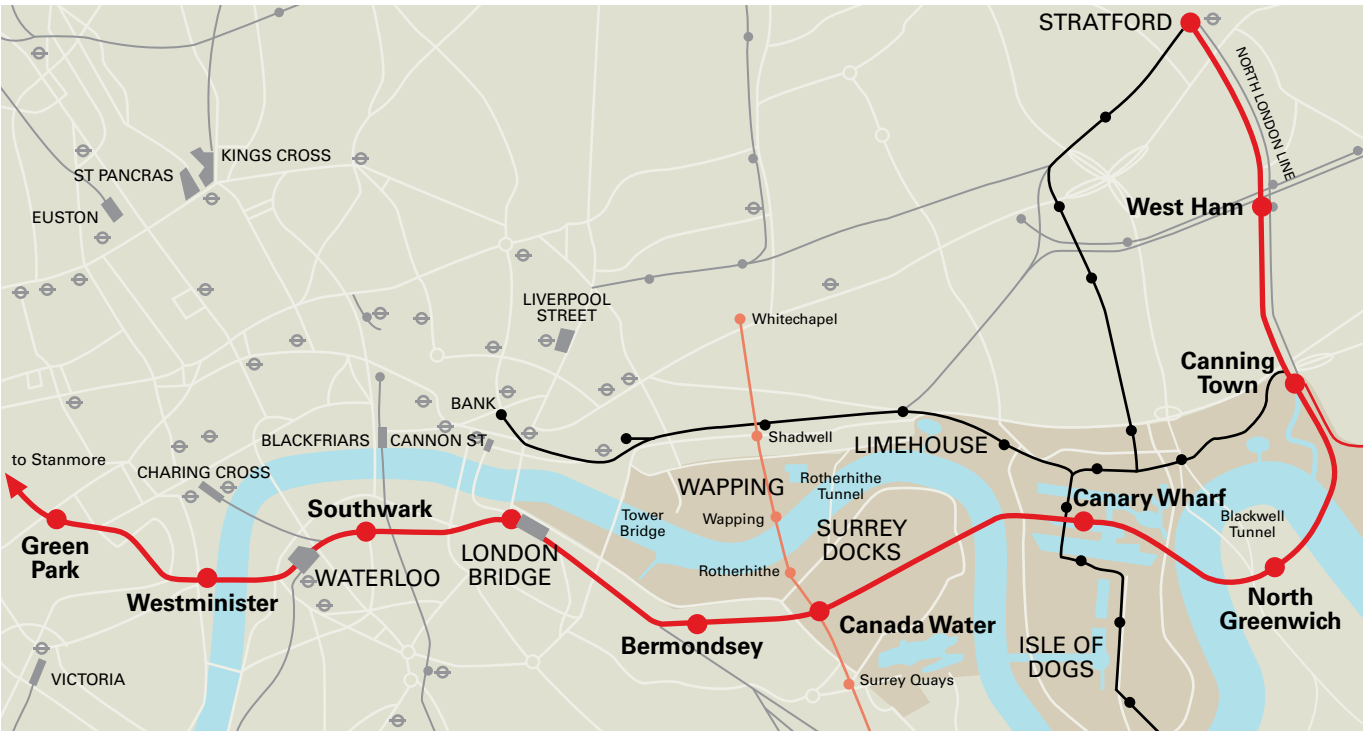
31. University of Westminster, Transport Studies Group, June 2004, 'JLE Summary Report: Final Report'.

32. Jones, P., Bray, J., & Powell, T., 2004, 'The Jubilee Line Extension Impact Study: Main Findings and Lessons Learnt', Association for European Transport

Figure 12: Docklands Light Rail



Figure 13: Jubilee Line Extension



Development of Docklands area

The better public transport connectivity provided by DLR and JLE has supported the regeneration of the Docklands area. The Canary Wharf Estate, which comprised 502,000 square metres in 1991, increased to 1.5 million square metres in 2003.³³ Similarly, residential development more than doubled between 1991 and 2000.³⁴

At the time of financial and political backing for the DLR and construction of Canary Wharf, the City of London was “bursting at the seams”; specifically there was a demand for new office space with large floorplates.³⁵ The DLR offered the opportunity for a new area to be integrated with the crowded City area. As such, the extension of the DLR to Bank Station was strongly supported by an international consortium of banks³⁶ which, as well as providing the private capital to back the initiative, also supported the £1.5 billion construction of Canary Wharf. The participation of the international consortium marked a vote of confidence in the Docklands becoming the international financial centre it has become today.³⁷

Analysis of major office relocations showed that the development of the Docklands had led to more companies and jobs being retained in Greater London than would otherwise been possible. In 1992, 14 per cent of all major

central London office relocations were to the Isle of Dogs. This was described as the “Docklands Effect”, marking that the supply stimulus resulted in more employment for London than if the new development had not occurred.³⁸

Transport to and from the Docklands was considered to be crucial to the attraction of demand for space in the area and the success of the Docklands as a whole. Specifically, the investments of the JLE in the reliability of the DLR Extension and growth of London City Airport were considered crucial in unlocking and underpinning the productive growth of these areas.

Employment growth

Since the opening of the JLE, employment in Canary Wharf grew at a much greater rate than the rest of London. As illustrated in Figure 14, employment in Canary Wharf almost quadrupled between 2000 and 2012 while employment in London only increased by 12 per cent in that period.

The employment growth in Canary Wharf was predominantly driven by the high value-add service sector. Between 2001 and 2012, the high value-add service sector grew by 283 per cent, while the secondary sector shrank by 13 per cent. The changes in employment across the various sectors are illustrated in Figure 15.



33. Jones, P., Bray, J., & Powell, T., 2004, 'The Jubilee Line Extension Impact Study: Main Findings and Lessons Learnt', Association for European Transport

34. Ibid

35. Westminster University, Property Market Study, Working Paper NMo. 32, October 2000, http://home.wmin.ac.uk/transport/jle/wp/WP32_Property_Market_Baseline_Study.pdf, accessed 13 June 2014

36. The consortium comprised of Financiere Credit-Suisse First Boston, Morgan Stanley International and First Boston Docklands Associates

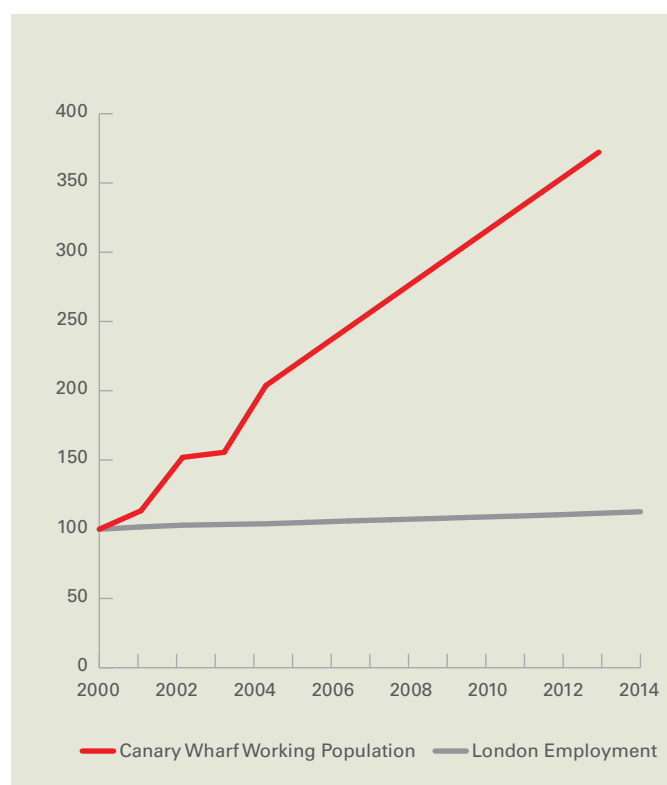
37. London Regional Transport, New City Rail Link to Docklands Proposed, 26 September 1985, <http://www.lddc-history.org.uk/pressreleases/dlr/PR260985.pdf>, accessed 13 June 2014

38. London Docklands Development Corporation, Docklands Keep Jobs in London, 5 February 1993, [http://www.lddc-history.org.uk/pressreleases/reports/Pr050293\(a\).pdf](http://www.lddc-history.org.uk/pressreleases/reports/Pr050293(a).pdf), accessed 13 June 2014

Of the various high value-add service sectors, financial and insurance activities created the largest amount of employment (58,500 jobs) in Canary Wharf in 2012. This is equivalent to 59 per cent of Canary Wharf's total employment. In 2012, the number of bankers employed in Canary Wharf overtook the number employed in the City of London. This makes it the biggest employer of bankers in Europe.³⁹ A survey of employers in the JLE Corridor showed a perception that the JLE helped integrate the local labour market into London and the South East, which led to an expansion of the recruitment catchment size.⁴⁰

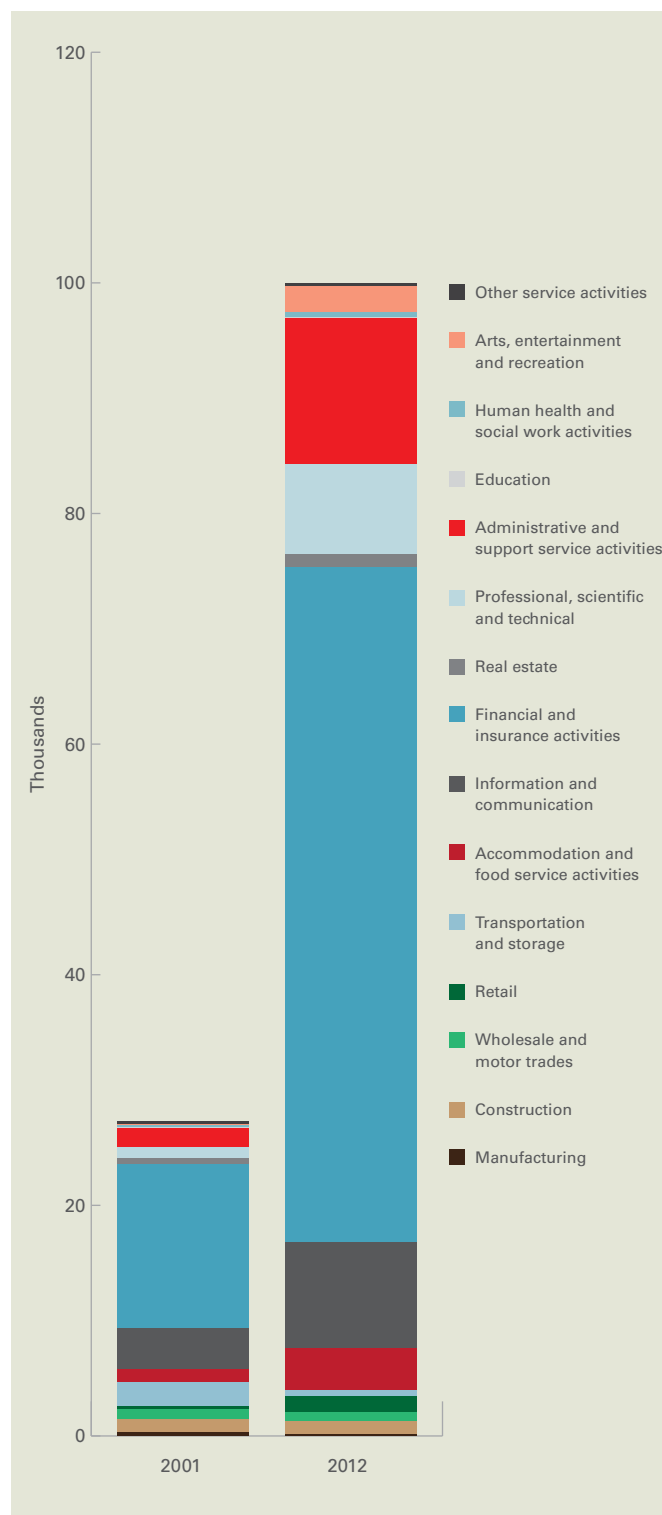
It is not possible to normalise and control for exogenous variables in order to understand the role transport directly played, as has been done with the Epping to Chatswood Rail Link. However, given the spatial location of the precincts and the industry composition of employment, there is little doubt that these transport investments were critical to both the initial and ongoing success of these locations.

Figure 14: Canary Wharf vs. London Employment (Index, 2000 = 100)



Source: Office of National Statistics, Regional Labour Market: H100 – Headline LFS Indicators for All Region, <http://www.ons.gov.uk/ons/rel/subnational-labour/regional-labour-market-statistics/february-2013/rft-lm-hi00-february-2013.xls>, accessed on 29th November 2013; and Transport for London, DLR history timeline, <http://www.tfl.gov.uk/corporate/modesoftransport/dlr/history/2982.aspx>, accessed 29 November 2013

Figure 15: Sectoral employment in Canary Wharf in 2001 and 2012



Source: Office of National Statistics, www.ons.gov.uk/ons/rel/regional-trends/london-analysis/small-and-large-firms-in-london-2001-to-2012/index.html, accessed 29 November 2013.

39. Financial Times, (2013) 'Canary Wharf workforce quadruples in a decade', 18 August 2013, <http://www.ft.com/cms/s/0/b06a7f6e-0440-11e3-8aab-00144feab7de.html#axzz2lvvyJlFX>, accessed 29 November 2013

40. Jones, P., Bray, J., & Powell, T., 2004, 'The Jubilee Line Extension Impact Study: Main Findings and Lessons Learnt', Association for European Transport

4.2.2 Economic Impact of Melbourne City Loop⁴¹

The City Loop was a recommendation put forth by the Metropolitan Town Planning Commission in 1929 due to congestion on the existing railway network. At the time, Flinders Street Station was one of the busiest railway stations in the world. However, interest in the City Loop waned during the Great Depression and the Second World War.

Interest in the City Loop was subsequently renewed in the 1950s, but it was only actioned following the 1969 Melbourne Transportation Plan.⁴² Construction of the Loop commenced in 1972 and it was opened in stages between 1981 and 1985.

The City Loop was built to relieve rail passenger congestion at Flinders and Spencer Street stations, enhance capacity of the network, and provide greater access to the northern areas of the central grid.⁴³ The City Loop also aimed to reduce the increasing use of cars in the CBD due to growing development in areas of Melbourne beyond walking distance from railway stations.⁴³

Development of Melbourne CBD

The success of the City Loop has supported the growth of the Melbourne CBD. There were a few key land use developments that occurred during the construction of the City Loop which simultaneously contributed to the CBD's growth. Thus, it is difficult to attribute all economic impact to the City Loop alone.

Overall, Melbourne CBD has changed significantly since the construction of the City Loop. Prior to the City Loop, the CBD north of Bourke Street was filled with two to three storey factories and warehouses, with the State Library and RMIT being the main attractions.⁴³ After the City Loop, the entire city block above the Melbourne Central loop station was redeveloped and the CBD extended its retail core of the city to La Trobe Street.⁴³ The overall CBD transformation was perceived to have a significant impact on the education precinct to the north of the CBD, as well as residential growth within the city.

Walk time impacts

The City Loop expanded the area of the CBD grid that is easily accessible by rail; in other words improving access to labour markets. The walk time between the northern areas in the CBD grid and the railway network decreased significantly after the City Loop was in place. Prior to the City Loop, the northern part of the CBD was up to a 30-minute walk from the train station. With the City Loop, majority of the CBD grid was within 15 minutes' walking time from a train station.

Improved accessibility of the northern part of the CBD had spurred a range of office developments in the area. Businesses that would previously consider setting up their offices in suburban locations (with physical proximity to labour markets) had slowly moved into the CBD, which had connectivity to labour improved by efficient mass transit.⁴⁴ The concentration of offices in the CBD further generated economic opportunities which supported the growth and development of these businesses.

Employment economic impact

The City Loop contributed to the increase in commercial development and employment in the CBD. The employment impact generated by the City Loop was estimated to be between \$1.27 billion and \$10.42 billion in 2011, where different scenarios of employment generation were considered.⁴⁵ These benefits are attributed to increased labour productivity, increased number of jobs in Melbourne, and move to more productive employment.⁴⁵

Increase in land value

Alongside the impacts, land value also increased due to the increased accessibility to/from the city and surrounding suburbs that was provided by the City Loop.

The average uplift in median house prices that was attributed to the City Loop was \$11,900 across Melbourne.⁴⁴ Given that there are approximately 1.22 million houses in Melbourne (in 2009), this translates into a one-off impact of \$13.2 billion on the economy.⁴⁴

41. SGS Economics & Planning, 2012, *Long run economic and land use impacts of major infrastructure projects*, p 31

42. Ibid, p 33

43. Ibid, p 33

44. Ibid, p 92

45. Ibid, p 91

05 CONCLUSION



CONCLUSION

A well-functioning transport system is vital to the productivity of all economies, including Australia's. This report provides new information that policy makers can use to ensure that future transport investments maximise the productivity of the Australian economy.

The report concludes that an efficient public transport system is critical for underpinning the future competitiveness of our high value-add service sector and by extension, our national economy. Therefore, any discussion on a competitive high value service sector needs to become synonymous with discussions on effective and efficient public transport systems in Australia's major cities.

The unique quantification of *ex-post* economic benefits from the Epping to Chatswood Rail Link then demonstrates the substantial returns that public transport investment can deliver. At one level, this analysis validates the theory behind what is expected to occur to wages, business profitability and tax revenues after the opening of mass public transport to an economic cluster that was previously had poor public transport access.

However, it also raises a number of secondary questions around the nature, potential transfer and longevity of these economic benefits. These questions need to be answered through additional studies and further monitoring of the economies influenced by the Epping to Chatswood Rail Link.

Six recommendations are provided to assist policy makers to realise the economic benefits associated with public transport investment to key locations. These recommendations incorporate the findings of this report into the planning, appraisal, prioritisation, funding and delivery of transport infrastructure. Adopting these recommendations will help ensure that Australia's future transport investments maximise the productivity of the Australian economy.

APPENDIX A: GEM

GEM captures the macroeconomic trends that shape Australia while also providing a more granular analysis of how the trends play out in 2,214 'locations' across Australia where business and government operate, covering 100 percent of the country. 'Locations' refer to socially and economically distinct areas that have, on average, a population of approximately 10,000 people.

For each of these locations, PwC can identify the core economic output of the 20 industries which make up the Australian economy from 2001 to 2013, with forecasts out to 2020. PwC can also estimate effects of innovation activity, agglomeration and productivity metrics, the wages received by employees and company profitability.

Economic performance can be tested and correlated to the other dimensions that are relevant. These include social and demographic factors, (for example age, income, education, housing density) access to transport and infrastructure, access to essential services, climatic conditions, customer preference, intention to purchase, crime statistics and more.

Understanding the spatial characteristics of the Australian economy allows a stronger, better understanding of the challenges it faces.

For further details and methodology see pwc.com.au



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